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on Various Phases of Thoracic Surgery

A Memorial to John Alexander (1891-1954)
Professor of Surgery, University of Michigan

Editor

JOHN D STEELE, M D
San Fernando, California

The Postoperative Chest

RADIOGRAPHIC CONSIDERATIONS AFTER THORACIC SURGERY

by

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Foreword

SURGICAL

It is universally accepted that the chest x ray is a very revealing and informative picture and permits the recognition of changes which are indicative of disease The perspicacity with which experts interpret shadows seen in the intact and anatomically undisturbed chest is truly amazing

When the chest is entered surgically shadows are recorded on the x ray film as in the undisturbed chest but interpretation becomes complex because of the addition of "postoperative" changes The postoperative film will reveal clearly the handiwork of the surgeon and serves as a yardstick with which to measure progress and to prognosticate the end result.

Thoughtful reflection upon the problems of interpretation presented in the postoperative chest x ray indicate at once the fact that many of the shadows recognized as deviations from the preoperative film are more or less *expected constants under the circumstances* Thorough familiarity with these expected changes and their proper evaluation sets the limits of the range of normal. *It is rather to be expected that the range of normal in the postoperative chest will be broader than in that of the intact and undisturbed thorax* since the same amount of postoperative edema, the same amount of residual hemothorax or pneumothorax or dressings etc need not occur from case to case

It is then evident that the appearance of a "postoperative chest" represents a composite of many usual and expected changes all *within the range of normal* for the given circumstance

An attempt to analyze these changes and break them down into their component elements has permitted greater assurance in prognosis In the present volume we are attempting to pass on to our readers the results of such analyses

The technical aspects of the surgical procedures are those commonly employed A posterolateral incision is preferred the pleura being entered through the bed of a resected rib Pulmonary resection is carried out by individual ligation of the vessels at the appropriate hilum, and the bronchus is likewise treated as an independent structure, being closed with simple sutures of silk

Drainage by one medium sized rubber tube evacuating the gutter inferiorly and posteriorly and placed intercostally is used after all thoracotomies except when pneumonectomy is carried out A smaller tube so placed in the axilla that it evacuates the upper anterior chest is generally employed in addition to the lower tube when a lung is partially resected

The post-pneumonectomy chest is rarely provided with tube drainage. Instead, intrapleural pressures are adjusted at thoracentesis by removal or addition of air, as determined by the patient's symptoms, or by the position of the mediastinum as seen on the x-ray, and/or the intrapleural pressures as read from a penumothorax manometer

The drainage tubes are led off to waterseal bottles as an initial step Suction is added to this system when indicated Our postoperative routines are kept as simple as is consistent with good care

RADIOLOGICAL

With the vastly increased volume of lung surgery being performed, the problem of interpreting postoperative chest radiographs has become increasingly important. In observing a rather large series of chest surgery cases, we were impressed by the number in which postoperative radiographs presented problems in interpretation, in which the "normal" was difficult to define The cases presented herein represent a resume of our experience

There are numerous papers in the literature concerning the various aspects of the expected postoperative changes after chest surgery and various complications encountered The majority of these papers concern a single phase of surgical change, and a few provide some general concepts of x-ray diagnosis in evaluating the postoperative chest film

Accordingly, we reviewed our material in an effort to separate the varying appearances encountered into proper categories, i e, changes of extrapleural soft tissues, ribs, pleura, lungs and mediastinum This approach helped us to define more adequately the expected changes in postoperative chests Deviations from these anticipated changes could then be classified as abnormal or representative of complications

We have classified the roentgen appearances encountered in our material in the following manner and have attempted to include examples of various categories

I Soft Tissues—Extracostal
- A Hematoma and edema
- B Air collections
  - 1 Incision
  - 2 Muscle
  - 3 Subcutaneous and fascial plane
  - 4 Air along neurovascular bundles
- C Subscapular space air-fluid collections

II Foreign Bodies
- A Drainage tubes
- B Dressings

C Pressure dressings
D Tape

III Ribs
A Resection
B Regeneration

IV Diaphragm
A. Elevation
B Adhesions

V Mediastinum
A Displacement
1 To surgical side
2 Away from surgical side
B Fluid
1 Increased "hilus" shadow
2. Mediastinal exudate
C Emphysema

VI Pleural Cavity
A Air fluid collection
1 General in pleural cavity
2. Primarily apical
3 Primarily anterior
4. Loculated
5 Basal
B Hematoma or unusual exudate
C Volume changes

VII Lungs
A. Rearrangement
1 Fissures demonstrated, posteroanterior and lateral views
2 Accessory fissures
B Bronchus stump
C Compensatory emphysema
D Herniation of lung
E Hematoma

VIII Complications
A. Excess air in soft tissues
B Pneumothorax
C Chronic pneumothorax or subscapular air
D Mediastinal emphysema
E Bleeding into soft tissues or pleural cavity
F Mediastinal displacement

G. Infection of surgical wound and/or empyema
H. Bronchopleural fistula
I. Infection about prosthesis
J. Atelectasis
K. Pneumonia

It has been our experience that routine x-ray studies performed with "high kilovoltage" technique consistently give more uniform radiographs and in general "yield" a greater number of lesions. Portable studies are utilized in the immediate post-surgical period. Our impression concerning our routine films was gained after using comparative studies with lower kilovolt techniques on all hospital admissions for a one-year period. Postero-anterior and lateral films are used routinely except in the immediate post-operative period.

Bilateral simultaneous bronchography is freely used as well as laminography in the anteroposterior and lateral views. Lateral laminography, incidentally, is utilized in many cases. This has proved of great value particularly preoperatively in predicting infiltration and cavity relationship to fissure, consequently the anatomic extent of disease. This procedure has been aptly described as a "bloodless thoracotomy" by one investigator. Thus, the surgeon can anticipate the extent of disease and determine whether definitive surgery should be preceded by pleural space diminishing procedures. Laminography, similarly, can be utilized postoperatively for the definition of infiltration, air collection and lung rearrangement.

Acknowledgments

THE UNUSUALLY fine line drawings and photographs for this monograph were prepared by Mr and Mrs L. S Pedigo of the photography department Presbyterian Hospital Chicago, and the manuscript was prepared and edited by Helene Coleman We are most grateful for their invaluable assistance

In addition Dr Karl Pfuetze Medical Director of the Chicago State Tuberculosis Sanitorium and Dr Roger Harvey Professor of Radiology University of Illinois College of Medicine made the case material available to us and offered most helpful suggestions

The publisher also made our task simpler with patience and excellent guidance

H T L
A M.P
M M

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The Postoperative Chest

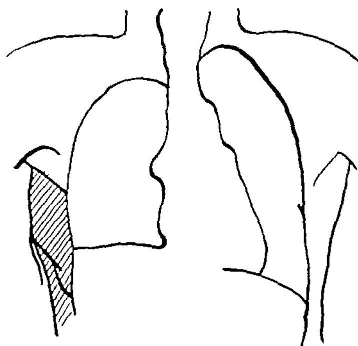
Fig. 1 *Incisional Swelling*

(A) One notes areas of soft tissue swelling along the right lower lateral chest wall This soft tissue change is one which is expected It consists chiefly of edema, minimal hematoma, and at times extracostal air collections In this particular case, air is not noted to good advantage, but subsequent illustrations will demonstrate various forms of subcutaneous and intramuscular air collections.

(B) Line drawing of (A)



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B

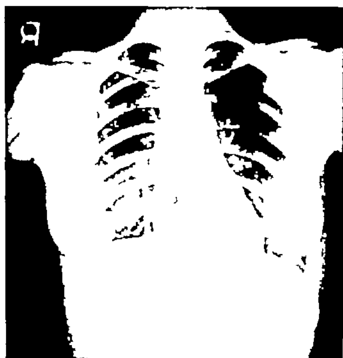
Fig 2 *Expected Postoperative Changes in Thoracotomy without Rib Resection*

(A) This is an early postoperative film. One will note the presence of surgical dressings, minimal soft tissue swelling in the lower portion of the inscision, pleural exudate, and an air fluid level in the right pleural base. The air fluid level represents a basal pneumothorax with minimal fluid in the dependent portion of the right pleural cavity. This is not considered a complication

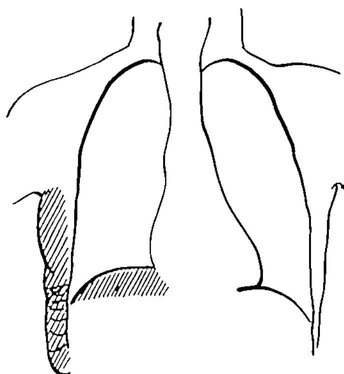
(B) Line drawing of (A)

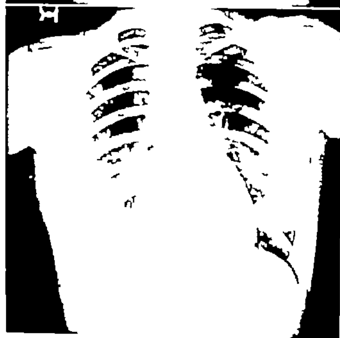
(C) This is an essentially normal chest, approximately one week following surgery Very minimal soft tissue swelling remains at the incisional site Otherwise, there is no evidence of the very recent surgery

A



B





C

Fig 3 *Incisional Air Collection*

(A) This is an excellent example of the demonstration of the surgical incision Due to a superficial infection in the posterior limb of the incision, separation of the skin has occurred The skin margins have become slightly separated so that air has become interposed between skin margins This is what is visualized in the x-ray It is noted that the incision passes immediately beneath the tip of the scapula The usual posterolateral thoracotomy incision starts in the periscapular space and courses inferiorly to the lower margin of the scapula and then across the latissimus dorsi muscle toward the axillary line

(B) Line drawing of (A)

Fig 4 *Extensive Muscular Subcutaneous and Cervical Air*

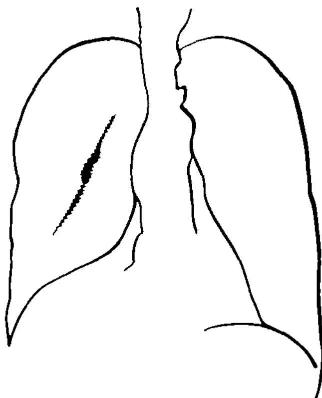
(A) This patient had severe pulmonary emphysema. A thoracotomy was performed and postoperatively there was leakage of a great deal of air into the soft tissues. The air spread bilaterally and outlined the pectoralis major muscles to very good advantage The emphysema is noted in the axillary tissues and extends into the supraclavicular areas and neck On close inspection of the neck shadows, one will note that air has travelled up the mediastinum, as is indicated by the vertical paravertebral radiolucent and slightly divergent lines in the neck portion of the film. Minimal mediastinal emphysema is also noted, as well as a small pneumothorax on the right Air in the neck region, which is continuous with the mediastinal space, is not readily distinguished from subcutaneous cervical air

(B) Line drawing of (A)

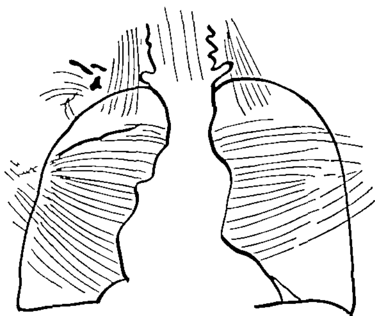
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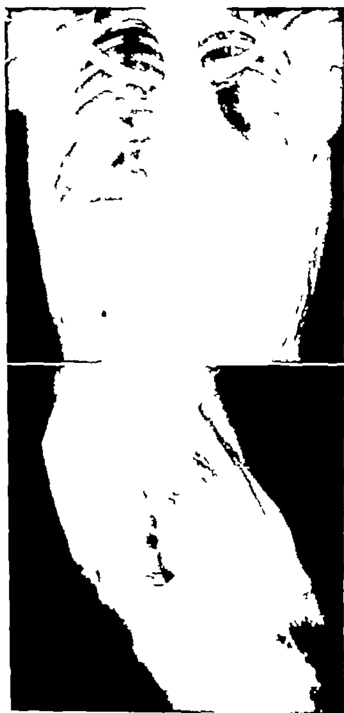
Fig 5 *Soft Tissue Air Collections (Intramuscular, Subcutaneous).*

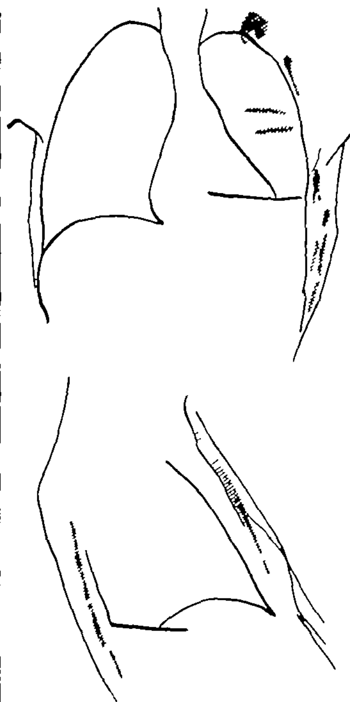
(A) and (C) This patient has undergone a left pneumonectomy Often, following a pneumonectomy, decompression of the remaining pneumothorax occurs and air will enter the soft tissues through defects in the wound closure This will occur in particular during episodes of straining or coughing In these radiographs one will note a moderate amount of intramuscular and subcutaneous air with demonstration of the pectoralis major muscle bundles. These are the almost transverse collections of air noted over the mid-left hemithorax. These changes are considered to be within normal limits although they do appear marked in the radiographs The lateral radiograph discloses to what extent the dissection of air has occurred along the anterior and posterior chest walls. A mantle of emphysematous air surrounds the thorax Expected post-pneumonectomy fluid collection in the left pleural base, as well as the expected incisional soft tissue swellings are noted (The PA film was taken three days after the lateral film)

(B) and (D) Line drawings of (A) and (C)

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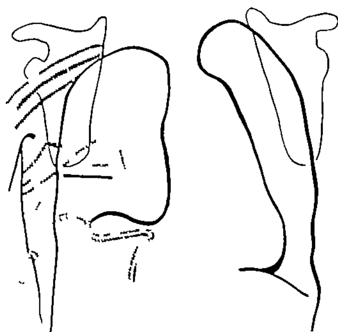
Fig 6. *Air Surrounding the Neurovascular Bundles in the Right Axillary Region.*

(A) This patient has undergone a pulmonary resection, which followed a tailoring thoracoplasty It was necessary to perform an extrapleural resection of the lung, and therefore the perivascular spaces and the pleural dome and root of the neck were entered during surgery This transgression of the anatomical planes allowed air from the pleural cavity to enter the neurovascular bundles in the axilla, and these are clearly demonstrated in this radiograph The radiolucent shadow representing air about the neurovascular bundle overlies the body of the scapula and courses distally parallel to the upper shaft of the humerus One will note there is little subcutaneous air Surgical dressings, soft tissue swelling at the operative site, and an opaque drain tube are also noted in the right hemothorax

(B) Line drawing of (A).



A



B

Fig 7 *Subscapular Fluid Collection after Tailoring Thoracoplasty with Compression of the Apex of the Lung*

(A) This demonstrates soft tissue changes following tailoring thoracoplasty with removal of the first three ribs The subscapular fluid collection causes compression of the apex of the right lung in an anterior and medial direction

(B) Line drawing of (A)

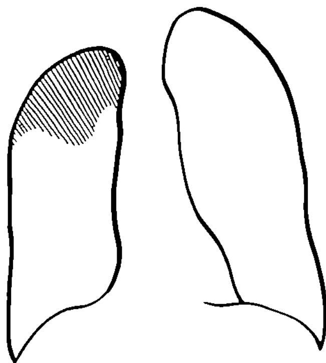
(C) Represents a roentgenogram taken one month later, with almost complete resolution of the soft tissue changes following the thoracoplasty procedure and re-expansion of the apex of the right lung

(D) Line drawing of (C)

A

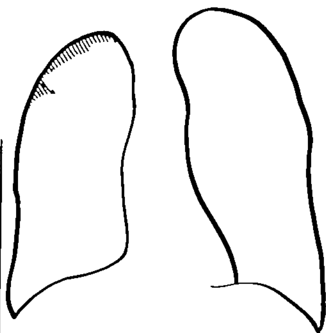


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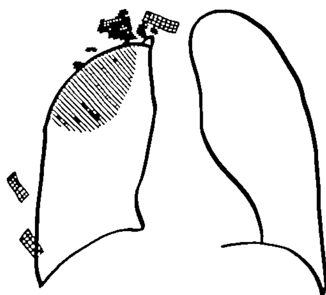
Fig 8 *Subscapular Air-Fluid Collection and Opaque Dressing*

(A) This patient had a recent tailoring thoracoplasty with resection of the first three ribs on the right side With such surgical procedure, a space is created in the subscapular area which normally becomes filled with fluid and air One will note that the air caps the subscapular space in this radiograph The air shadow lies within a space created by the surgery and its margins are irregular This irregular shadow is outside the confines of the right pleural cavity The changes described are within normal limits for the early postoperative stage Incidentally, this radiograph also demonstrates a type of radiopaque marker used within gauze dressings

(B) Line drawing of (A)



A



B

Fig 9 *Subscapular Air Fluid Collection with Compression of the Lung and Subsequent Re-expansion (Standard Thoracoplasty)*

(A) This patient underwent a standard type thoracoplasty In this procedure the entire length of the 1st, 2nd, and 3rd ribs was resected The resection was carried forward to include the tip of the cartilage, and posteriorly to include the transverse processes of the 2nd and 3rd dorsal vertebrae The 1st rib head and the first transverse process were not resected The film demonstrates a large subscapular air fluid collection with obvious depression of the apex of the lung on this side

(B) Line drawing of (A)

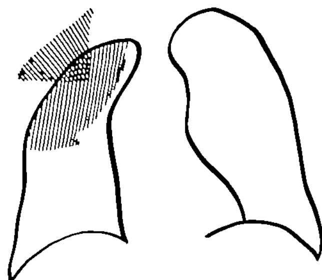
(C) Represents a film taken about one week later, and demonstrates that partial resorption of air and fluid in the soft tissues has occurred, with considerable re-expansion of the apex of the right lung This rate of change is within normal limits

(D) Line drawing of (C)

A



B







D

C

Fig 10 *Subscapular Air Collection with Compression of Apex of Left Lung and Subsequent Re-expansion of the Apex of the Lung*

(A) This x-ray reveals the subscapular collection of fluid and air compressing the apex of the left lung in the early post-operative state after a tailoring thoracoplasty The lung is compressed in an anteromedial direction

(B) Line drawing of (A)

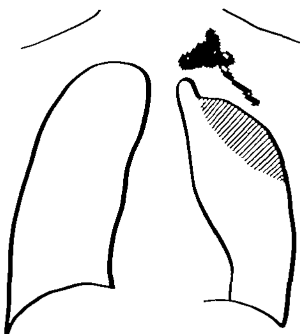
(C) A lateral view of the subscapular fluid collection already described

(D) Line drawing of (C)

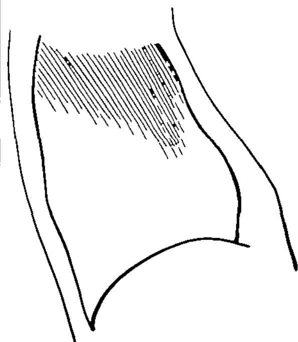
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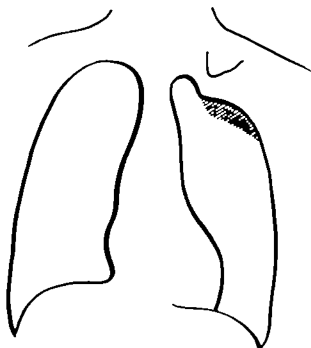
Fig 10—(*Continued*) *Subscapular Air Collection with Compression of Apex of Left Lung and Subsequent Re-expansion of the Apex of the Lung*

(E) Represents a posteroanterior chest film taken one month later, and reveals re-expansion of the left lung and complete resolution of the air fluid collection in the subscapular space previously described

(F) Line drawing of (E)



E



F

Fig 11 *Drainage Tube*

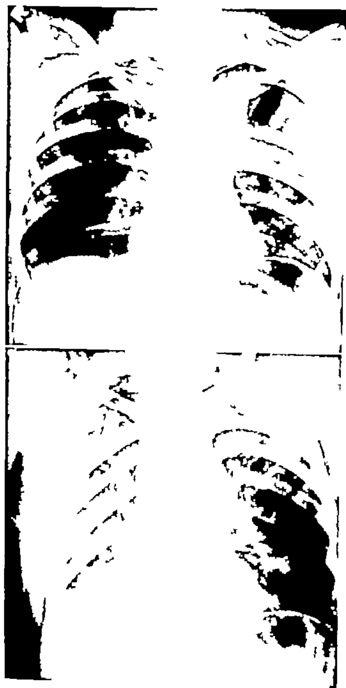
(A) This film represents an early postoperative x-ray following segmental resection The principal feature in the film is a clearly outlined soft rubber tube, running obliquely from the costophrenic angle up into the gutter toward the dome of the pleural cavity Air within the lumen of the tube helps to outline its borders A small pneumothorax is also noted

(B) Line drawing of (A)

Fig 12 *Drainage Tube and Surgical Dressings*

(A) This is an early postoperative film following segmental resection of the right upper lobe It demonstrates well a residual pneumothorax within the right pleural space situated superiorly Curving across the bed of the resected rib in this projection is the shadow cast by a small anterior drainage tube Emerging from the dressings in the base of the same side is another tube, likewise of soft rubber, which is placed to drain the gutter posteriorly, but is not seen to good advantage in the roentgenogram Over the soft tissues of the chest wall, one will note the presence of dressings and the curvilinear lacy network of folded tape can easily be recognized.

(B) Line drawing of (A)


A
A

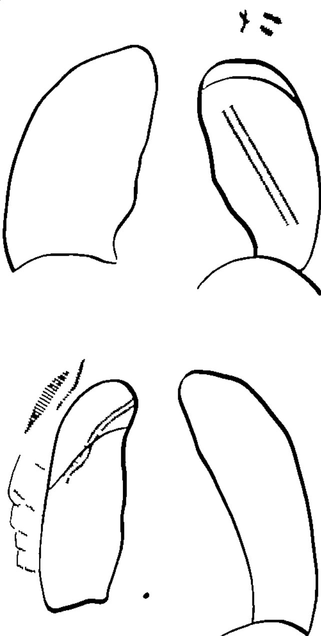

B
B

Fig 13 *Pressure Dressings and Opaque Markers*

(A) This is an early postoperative x-ray following a right lower lobectomy A small amount of residual loculated pneumothorax is noted at the right base medially It has been sufficiently long after the resection that the subcutaneous air initially present has been absorbed. Still noted over the lungs are two rectangular shadows of opaque material These represent dressings over the wound, which was a posterolateral thoracotomy in which x-ray markers appear Of further interest is the fact that on removal of the tube a pressure dressing, supported by tape, is placed over the drain tracts and this is clearly in evidence in the crescentic outline of the tape in the lower thoracic cage laterally

(B) Line drawing of (A)

Fig 14 *Rib Regeneration*

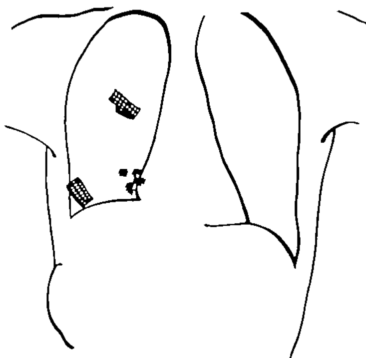
(A) This is a chest x-ray taken some time after a segmental lobectomy in the right upper lobe and shows excellent clearing of any pleural residuals There is minimal apical cap remaining, which is a vanishing shadow when compared to previous films An interesting feature of this film is the clear cut demonstration of rib regeneration at the site of closure of the periosteal membrane along the rib that was originally resected It shows the regeneration rather clearly traceable from the posterior resected rib stump to the anterior resected rib stump The evidence for rib regeneration appears approximately five to six weeks in most instances and thereafter becomes somewhat denser

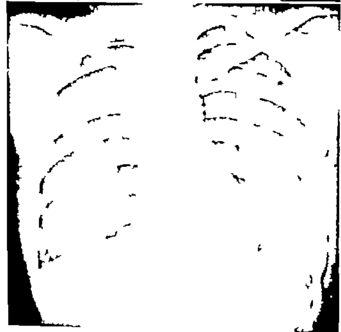
(B) Line drawing of (A)

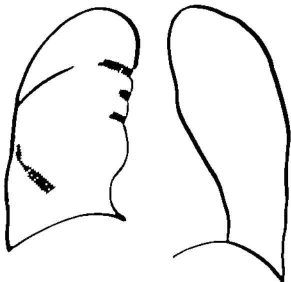
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B

Fig 15 *Pressure Dressings, Pleural Reaction, and Possible Elevation of Diaphragm*

(A) This represents an early postoperative film with a bulging pressure dressing noted inferiorly, and pleural change at the right base The right diaphragmatic leaf may be slightly elevated but this is difficult to prove in view of the pleural reaction present

(B) Line drawing of (A)

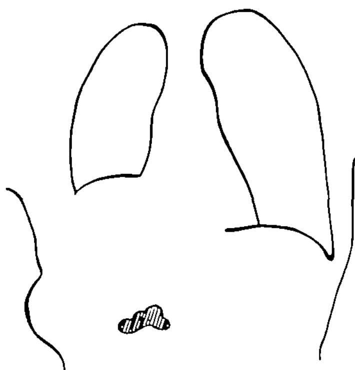
(C) This film, approximately one year later, shows clearing of the previously described pleural reaction and the right diaphragmatic leaf is now essentially normal in position The partially regenerated rib is also noted This postoperative appearance is satisfactory.

(D) Line drawing of (C)

A

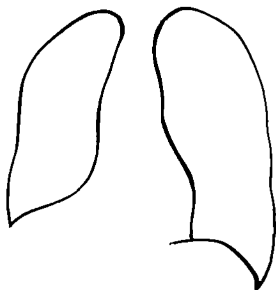


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Fig 16 *Diaphragm Elevation*

(A) This film, taken shortly after a right upper lobectomy, shows the usual changes in the soft tissues and the persistent pneumothorax that would indicate the recency of the resection. Likewise the presence of a high diaphragm leaf is to be noted on the operated side.

(B) Line drawing of (A).

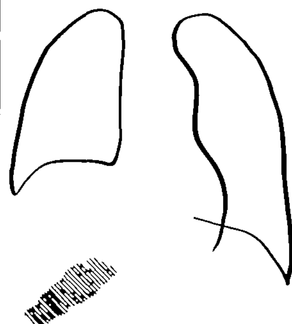
(C) The subsequent film, taken two and one-half months later, shows the persistent high diaphragm. The explanation for the elevation of the diaphragm here is that the phrenic nerve was injured during the course of resection and therefore this represents a paralyzed diaphragm This diaphragm is demonstrated to be paralyzed at fluoroscopy.

(D) Line drawing of (C)

A

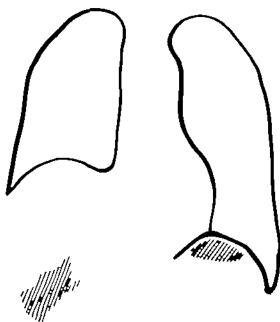


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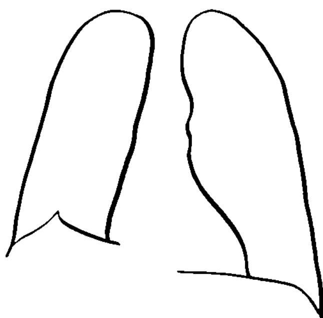
Fig 17 *Tenting Adhesions, Right Base, Post Right Upper Lobectomy*

(A) This film, taken eight weeks postoperatively, reveals a tenting of the right diaphragmatic leaf resulting from a pleural adhesion in this region

(B) Line drawing of (A).



A



B

Fig 18 *Mediastinal Position after Pneumonectomy*

(A) The position of the mediastinum is of interest It will be noted that the mediastinum is displaced somewhat toward the unoperated side in the early postoperative stage This is due to the fact that at the time of pneumonectomy adjustment of pleural pressure brings them to an approximately neutral level The balance of pressure between the neutral level in the empty hemithorax and the negative pressure of the intact chest determines the ultimate position of the mediastinum

(B) Line drawing of (A).

(C) Represents a film taken two days later, with adjustment of the pressures and removal of approximately 100 cc of air. The mediastinum is closer to the ideal position and there is now noted effusion in the left pleural cavity This increasing fluid is a normal situation and constitutes no indication of impending complication Mediastinal emphysema can also be noted

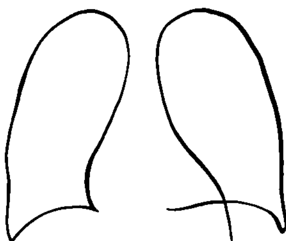
(D) Line drawing of (C)

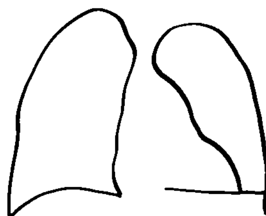
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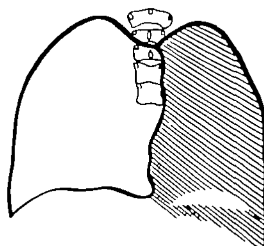
Fig 18—(*Continued*). *Mediastinal Position after Pneumonectomy*

(E) Postoperative film, taken about six weeks later, shows the left hemithorax to be completely opaque, the left diaphragmatic leaf to be slightly higher than the right one and the mediastinum to be pulled toward the operated side This represents shrinkage which has occurred in the organizing exudate that ultimately filled the pneumonectomy space.

(F) Line drawing of (E)



E



F

Fig 19 *Probable Clot Extending Above Air Fluid Level in Pleural Space Mediastinal Shift Lung Herniation*

(A) Early post-pneumonectomy film, in which the mediastinum is displaced markedly away from the surgical side to the right, and in which there is a fluid level occupying the lower pleural cavity on the left The density which is seen to extend above the air fluid level is interpreted to be a blood clot. This is thought to represent the result of the patient lying in a recumbent position in which the clot becomes adherent posteriorly, giving the impression of a mass extending above the air fluid level described. The extreme position of the mediastinum is abnormal and should be corrected. It is also to be noted that the stomach is distended and, if not corrected, this may further account for the disability of the patient

(B) Line drawing of (A)

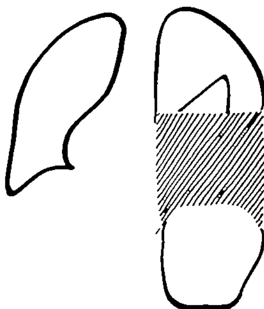
(C) Approximately one week later, reveals almost complete resorption of the air previously seen in the left pleural cavity. Small air fluid loculations are still present, and there remains slight mediastinal shift toward the right.

(D) Line drawing of (C)

A



B





C



D

Fig 19—(*Continued*) *Probable Clot Extending Above Air Fluid Level in Pleural Space. Mediastinal Shift. Lung Herniation.*

(E) Reveals a satisfactory appearance post-pneumonectomy with opacification of the left hemithorax by exudate and mediastinal shift toward the operated side Lung herniation is also noted

(F) Line drawing of (E).

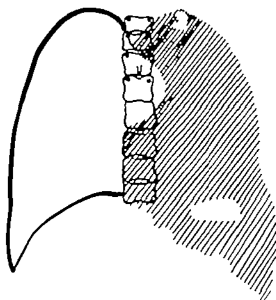
(G) Posteroanterior film, post-pneumonectomy, approximately ten months after surgery, with diminished volume of the left pleural cavity and lung herniation increased since the previous study.

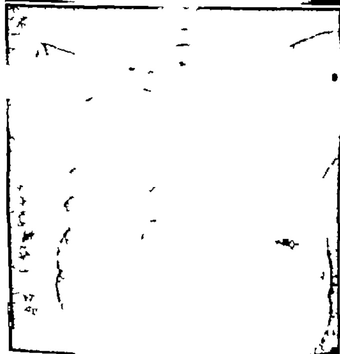
(H) Line drawing of (G).

E

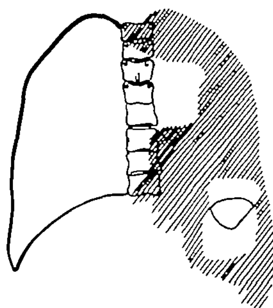


F





G



H

Fig 19 —(*Continued*) *Probable Clot Extending Above Air Fluid Level in Pleural Space Mediastinal Shift. Lung Herniation*

(I) Lateral view, post-pneumonectomy, ten months after surgery

(J) Line drawing of (I)



I

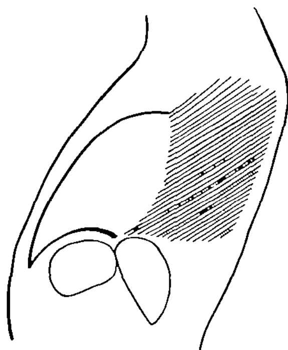


Fig 20 *Prominent Lung Root Shadow.*

(A) A prominent right hilar root shadow is noted We have frequently seen this, particularly after resection of the right upper lobe This enlargement fades to normal size at about the same rate at which the pleural reaction subsides postoperatively We believe this shadow is due to clot or exudate trapped at the lung root by the overlapping lung as it expands

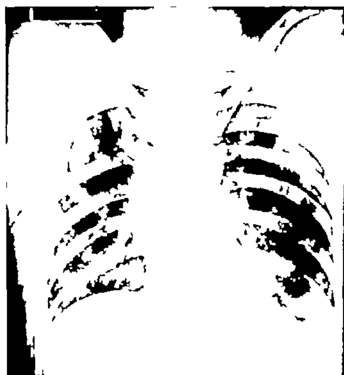
(B) Line drawing of (A)

Fig 21 *Mediastinal Exudate*

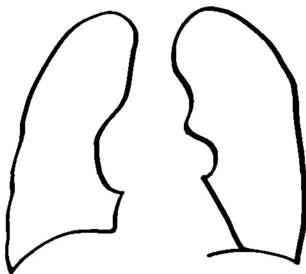
(A) The immediate postoperative chest film reveals widening of the mediastinum at the level of the aortic arch and superior to the level of the aorta There also appears to be enlargement of the hilar root shadow to a minimal extent on the left side This is thought to represent pleural change with exudate which should not be construed as complication.

(B) Line drawing of (A)

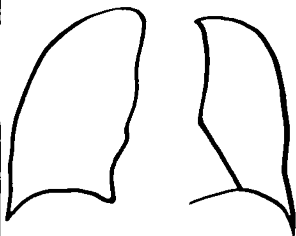
A



B







B

A

Fig 22 *Mediastinal Exudate with Prominent Hilar Shadow*

(A) This early postoperative film demonstrates a widened mediastinum by mediastinal exudate which is contiguous with a pleural exudate and a prominent right hilar shadow These are rather common findings following right upper lobectomy

(B) Line drawing of (A)

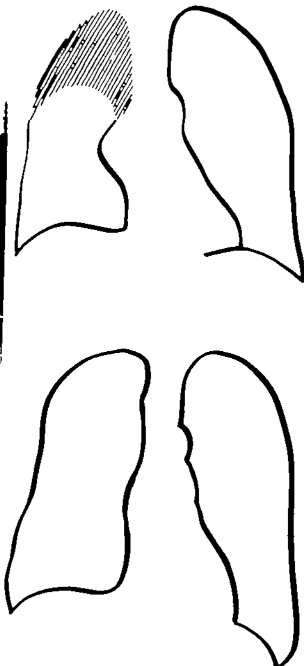
(C) Film fourteen months after surgery reveals a normal postoperative appearance with no complication. There has been resolution of the mediastinal exudate and the right hilar shadow now has a normal postoperative appearance.

(D) Line drawing of (C).

A

B





C

D

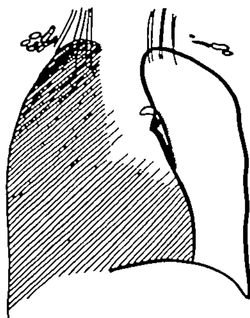
Fig 23 *Mediastinal Emphysema*

(A) In addition to the extensive subcutaneous emphysema noted in the supraclavicular area, emphysematous changes in the mediastinum are clearly in evidence One notes that there is dissection of air into the space between the aorta and the left mediastinal pleura

(B) Line drawing of (A)



A



B

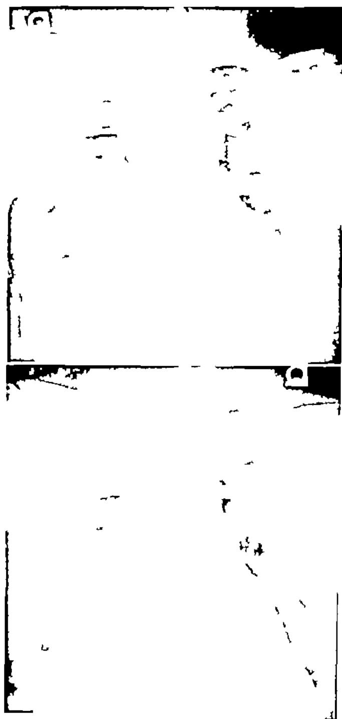
Fig 24 *Minimal Postoperative Changes Following Right Upper Lobectomy*

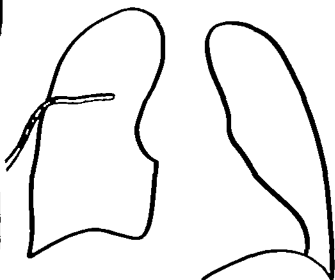
(A) This posteroanterior film illustrates the minimal findings which may be present after surgery Actually there is little change in the film except for minimal pleural reaction medially and small soft tissue air collections An opaque catheter is seen, as well as resection of the right 5th rib

(B) Line drawing of (A)

(C) Reveals that after the right upper lobectomy, the right pleural cavity appears almost normal There remains only a tiny air collection in the soft tissues of the right hemithorax This film was taken three days after surgery.

(D) Line drawing of (C)





D

Fig 25 *Apical Air Fluid Collection with Resolution Rearrangement of Fissures.*

(A) The posteroanterior chest film reveals a residual loculation of air and fluid in the apex of the right pleural cavity Minimal pleural reaction is also noted at the right base This is the usual occurrence The remaining right lower and middle lobes now occupy the greatest portion of the right pleural cavity These lobes thus are overdistended in order to fill the pleural cavity.

(B) Line drawing of (A)

(C) Lateral postoperative film reveals the air fluid loculation described with fluid dipping into the fissure and illustrating the rearrangement of the lower and middle lobes

(D) Line drawing of (C)


A
B
C
D

Fig 26 *Pleural Loculations Post-Right Upper Lobectomy and Rearrangement of Lobes*

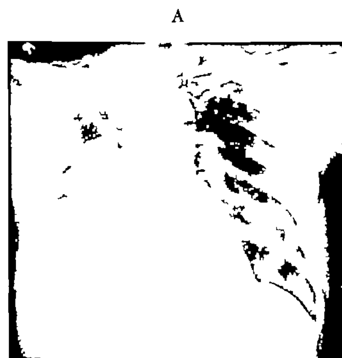
(A) The early postoperative film in the PA view discloses the presence of pleural reaction in rather typical location The apical portion of the right pleural cavity is filled with fluid and pleural exudate A loculated pleural effusion is noted posterior to the lower lobe also This appears to be a favored area for loculation of pleural fluid and it is probably related to the patient's recumbent position in the early postoperative period At times apparent elevation of the right diaphragmatic leaf can be at least in part due to infrapulmonary effusion

(B) Line drawing of (A)

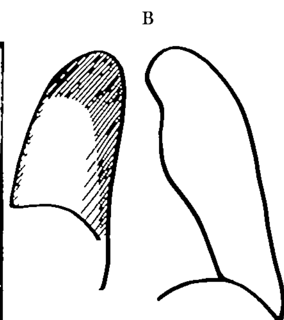
(C) Lateral view showing the distribution of the pleural reaction described and the redistribution of lobes The middle lobe is seen to be anterior to the long fissure and is partially covered by pleural exudate The lower lobe is seen posterior to the fissure level A posterior pleural loculation is also noted

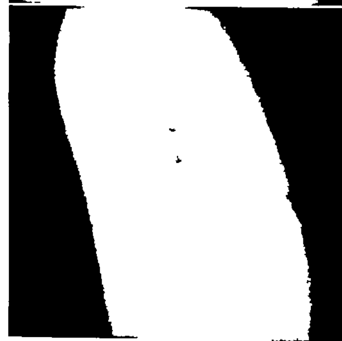
(D) Line drawing of (C)

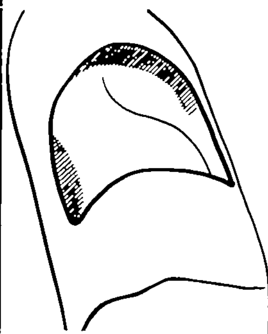
A



B







C

D

Fig. 27 *Expected Pleural Changes Following Right Upper Lobectomy*

(A) Reveals expected apical and mediastinal exudate collection as well as generalized minimal pleural change following right upper lobectomy. The lung root shadow is enlarged as a result of exudate collection in this region and/or blood clots The right diaphragmatic leaf contour appears slightly elevated Minimal subpulmonary fluid collection is not excluded

(B) Line drawing of (A)

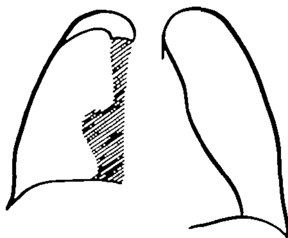
(C) Film taken one day later shows findings similar to those previously described and well defined

(D) Line drawing of (C)

A

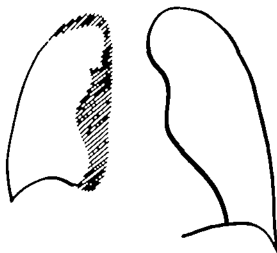


B





C



D

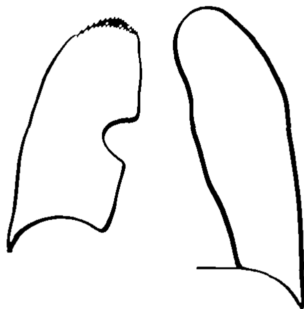
Fig. 27.—(*Continued*). *Expected Pleural Changes Following Right Upper Lobectomy.*

(E) Eight months later, reveals a normal postoperative appearance without evidence for complications The previously described pleural reaction has completely subsided. Very minimal pleural changes are still present.

(F) Line drawing of (E)



E



F

Fig. 28 *Ascending Fluid Level, Post-pneumonectomy Mediastinal Shift*

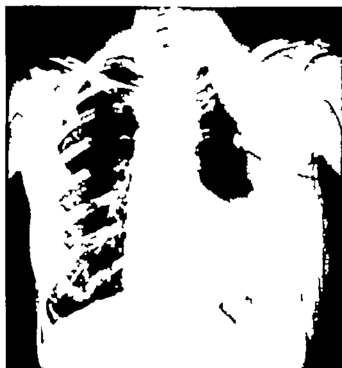
(A) Early postoperative film, post-pneumonectomy reveals the mediastinum to be situated in the midline with an air fluid level in the lower portion of the left pleural cavity The left diaphragmatic leaf is slightly elevated Note the partial thoracoplasty

(B) Line drawing of (A)

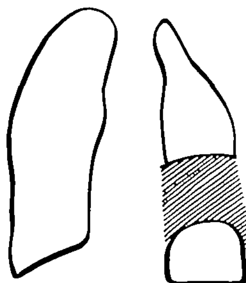
(C) Film taken approximately five weeks later, reveals increased exudate and fluid in the left pleural cavity with the air fluid level previously described now seen to be situated at a higher level, which is the normal course of events The mediastinum is now seen to be shifting toward the operated side

(D) Line drawing of (C)

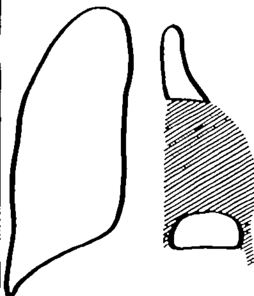
A



B







D

C

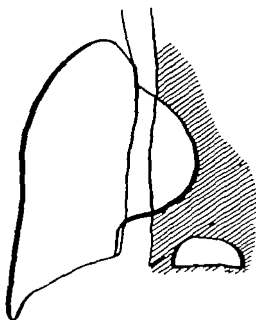
Fig 28—(*Continued*) *Ascending Fluid Level, Post-pneumonectomy Mediastinal Shift*

(E) Eight weeks postoperatively, now reveals the left pleural cavity to be completely opacified There is no longer evidence for pneumothorax The mediastinum is completely shifted into the left pleural cavity Minimal herniation of the right lung toward the left is noted

(F) Line drawing of (E)



E



F

Fig 29 *Basal Pneumothorax General Pneumothorax*

(A) The early postoperative films reveal a generalized pneumothorax but in addition there is a triangular shaped pneumothorax, as seen in this projection at the base of the left pleural cavity This is not an unusual finding immediately postoperatively

(B) Line drawing of (A).

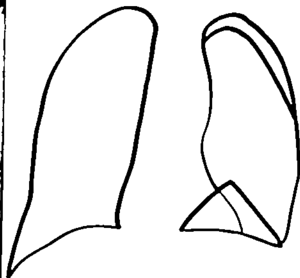
(C) The basal air collection previously described is no longer identified and this area is now seen to be opaque, being filled with pleural exudate and fluid.

(D) Line drawing of (C)

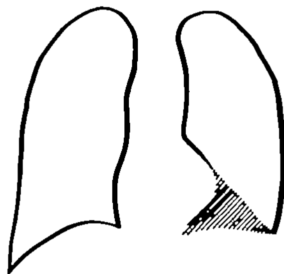
A



B







D

C

Fig 30 *Anterior Pneumothorax*

(A) Reveals an early postoperative chest film after upper lobectomy In this film it was most difficult to identify a distinct pneumothorax

(B) Line drawing of (A)

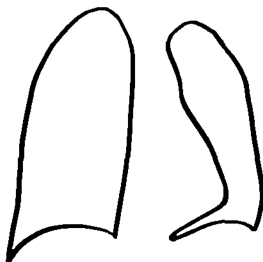
(C) Lateral view, early postoperative stage, reveals a very definite anterior pneumothorax The lower lobe is seen to occupy the lower and posterior portion of the pleural cavity on the left side, but does not extend completely to fill the pleural cavity It is not unusual to have a pneumothorax present and not readily visible in the posteroanterior roentgenogram of the chest, but easily demonstrable in the lateral view

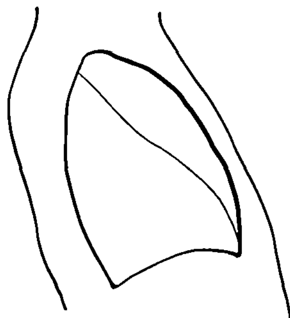
(D) Line drawing of (C)

A

B







C

D

Fig 30—(*Continued*) *Anterior Pneumothorax*

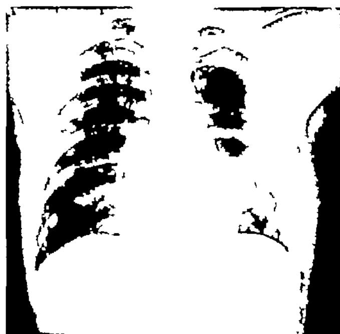
(E) Four days later there is a very definite pneumothorax identifiable on the left side, even in the posteroanterior projection.

(F) Line drawing of (E)

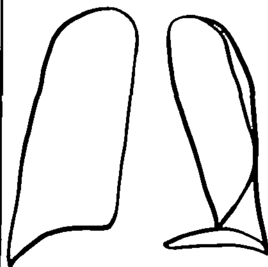
(G) Film taken six days after the preceding, in posteroanterior projection, reveals partial replacement of the anterior pneumothorax by pleural exudate and fluid with an air fluid level In usual circumstances, when a small amount of pneumothorax is present, the air is eventually completely replaced by fluid and exudate and subsequently diminishes as the remaining lung expands The case represents an exaggeration of this phenomenon

(H) Line drawing of (G).

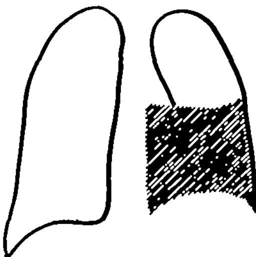
E



F







G

H

Fig 30 —(*Continued*) *Anterior Pneumothorax*

(I) Lateral view of same

(J) Line drawing of (I)

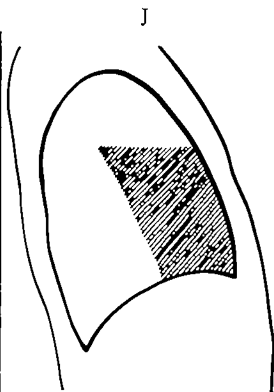
(K) Reveals replacement of the pneumothorax by fluid and exudate and further re-expansion of the left lower lobe

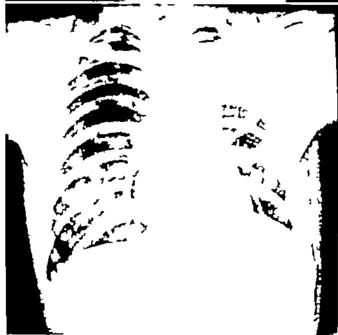
(L) Line drawing of (K)

I

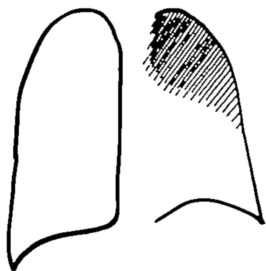


J





K



L

Fig 30—(*Continued*) *Anterior Pneumothorax*

(I) Lateral view of same

(J) Line drawing of (I)

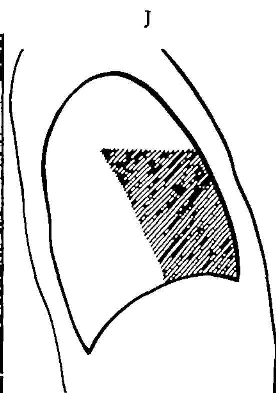
(K) Reveals replacement of the pneumothorax by fluid and exudate and further re-expansion of the left lower lobe

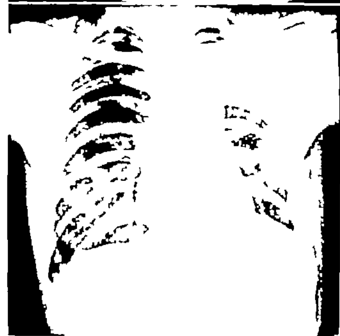
(L) Line drawing of (K)

I

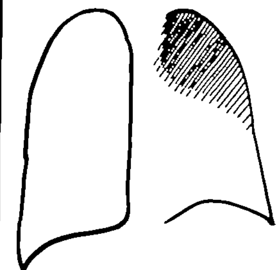


J





K



L

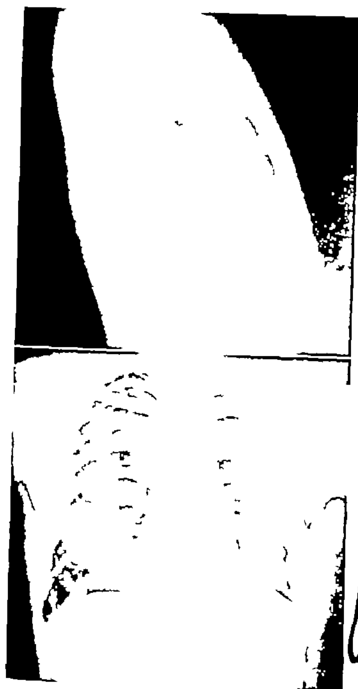
Fig 30—(*Continued*) *Anterior Pneumothorax*

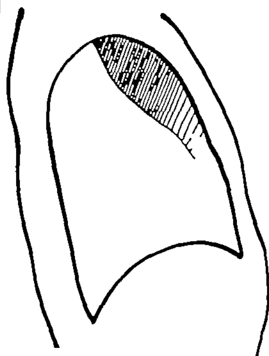
(M) Lateral view of (K) approximately one month after surgery

(N) Line drawing of (M)

(O) Approximately four months after surgery, shows resolution of the air fluid collection previously described to be almost complete as seen in this projection.

(P) Line drawing of (O)


M
O


N

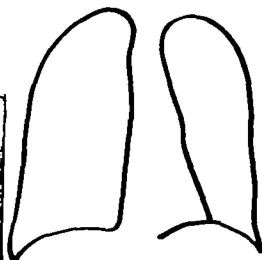

P

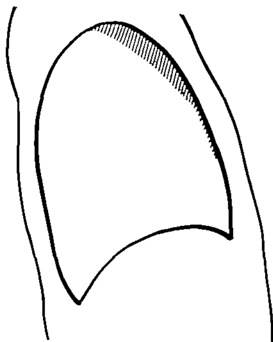
Fig 30—(*Continued*) *Anterior Pneumothorax*

(Q) Lateral view, four months postoperatively, reveals that there remains a small pleural collection anteriorly but that the left lower lobe has almost completely expanded to fill the left pleural cavity.

(R) Lateral view of (Q)



Q



R

Fig 31 *Pneumothorax, Anterior*

(A) Reveals a large pneumothorax in the early postoperative film after resection of the right upper lobe, as well as a wedge resection of the middle lobe and superior division of the lower lobe

(B) Line drawing of (A).

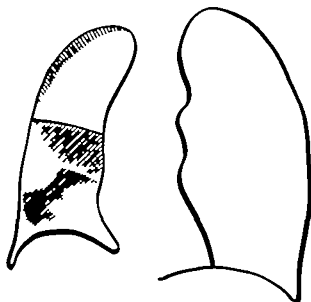
(C) The pneumothorax on the right is considerably diminished since the previous examination

(D) Line drawing of (C).

A

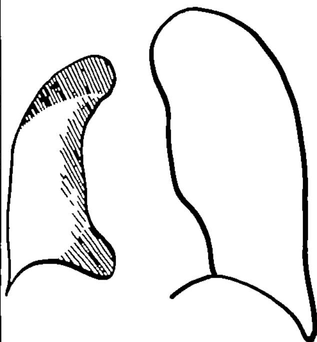


B





C



D

Fig 31 —(*Continued*) *Pneumothorax, Anterior*

(E) One month later, reveals apparent good expansion of the remaining right lung with questionable evidence for pneumothorax over the apex Small infiltrations are also seen at the right lung base

(F) Line drawing of (E)

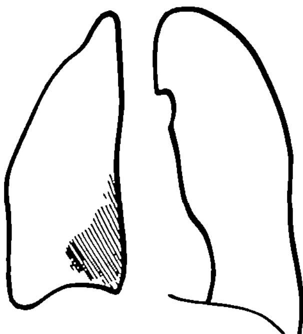
(G) On the lateral film, however, there is noted a large pneumothorax anteriorly, which is entirely unsuspected from the available posteroanterior film

(H) Line drawing of (G).

E

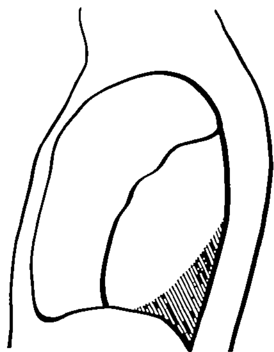


F





G



H

Fig 31 —(*Continued*) *Pneumothorax, Anterior.*

(I) An opaque catheter is now seen *in situ* and there is slightly increased pleural change in an examination performed the next day

(J) Line drawing of (I)

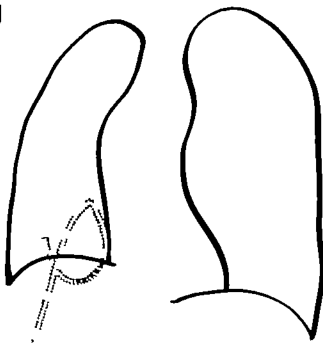
(K) Approximately two weeks later, reveals an air fluid loculation over the right apex with no additional findings noted

(L) Line drawing of (K)

I

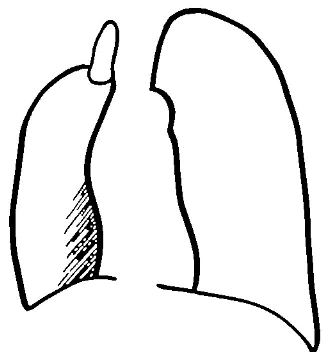


J





K

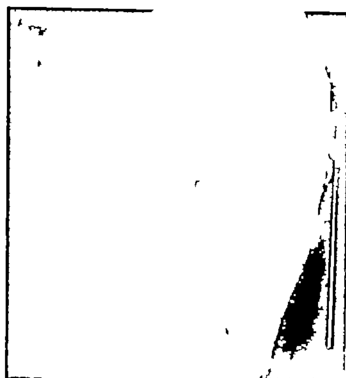


L

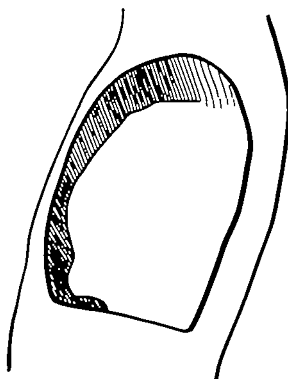
Fig 31—(*Continued*) *Pneumothorax, Anterior*

(M) A lateral view reveals that the anterior pneumothorax is considerably diminished Pleural collections are also noted with no additional findings.

(N) Line drawing of (M)



M



N

Fig 32 *Multiple Pleural Loculations Elevated Diaphragm Leaf*

(A) Posteroanterior film reveals multiple air fluid loculations in the left pleural cavity after resection of all of the left lung except the lingular segment of the left upper lobe and the basal segments of the left lower lobe The apparent contour of the left diaphragmatic leaf is elevated as evidenced by elevated fundic shadow of the stomach There may in addition be some fluid at the base of the left pleural cavity

(B) Line drawing of (A)

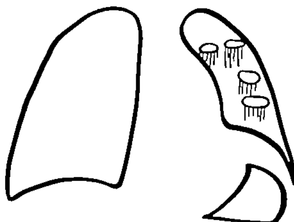
(C) Lateral view of (A)

(D) Line drawing of (C)

A

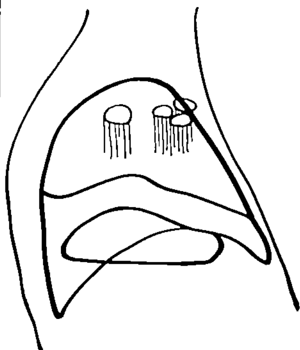


B





C



D

Fig 32—(*Continued*) *Multiple Pleural Loculations Elevated Diaphragm Leaf*

(E) Diminished air collections on the left are noted Slight increase of pleural reaction on the left is also to be seen

(F) Line drawing of (E)

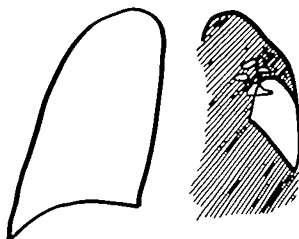
(G) Approximately ten months later, reveals an excellent postoperative appearance with resolution of the previously noted air fluid collections in the left pleural cavity Only the slightest elevation of the left diaphragmatic leaf is seen There are no complications

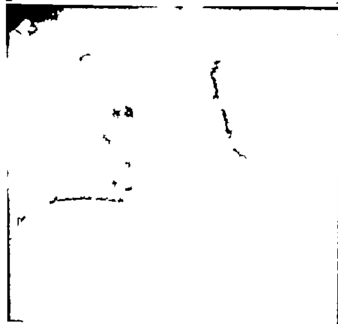
(H) Line drawing of (G)

E

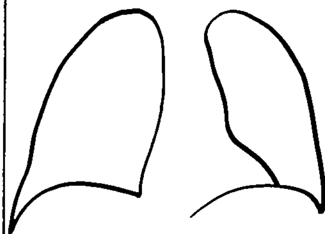


F





G



H

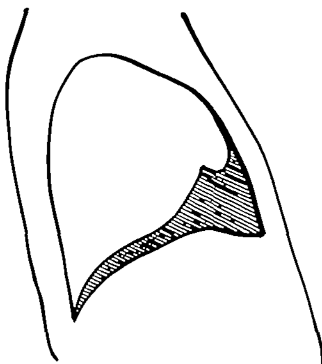
Fig 32 —(*Continued*) *Multiple Pleural Loculations Elevated Diaphragm Leaf*

(I) Lateral view late postoperative appearance

(J) Line drawing of (I)



I



J

Fig 33 *Multiple Pleural Loculations*

(A) Multiple fluid loculations are seen in the superior portion of the right pleural cavity after resection of the right upper lobe and apical division of the lower lobe An ill-defined density over the more inferior portion of the lung field is produced by a posterior pleural loculation seen best in the lateral view This should not be confused with lung infiltration

(B) Line drawing of (A)

(C) Lateral view reveals the posterior fluid loculation seen as an ill-defined density overlying the lower portion of the right lung in the PA view In addition, one may see the rearrangement of lobes with the middle lobe anteriorly and superiorly, and the lower lobe posteriorly and inferiorly

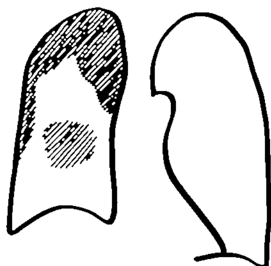
(D) Line drawing of (C)

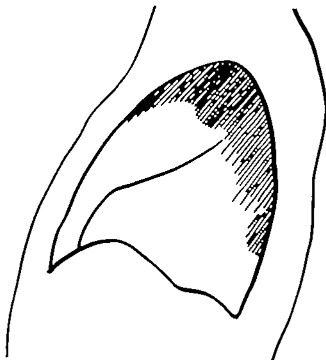
A



C

B





D

Fig 34 *Apical Pneumothorax*

(A) Reveals the presence of an apical air space which has persisted for two months following right upper lobectomy that was otherwise uncomplicated This space slowly disappeared

(B) Line drawing of (A)

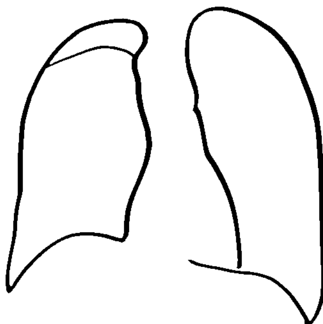
(C) A film six months later shows the apical air space to have disappeared with now apparently complete filling of the apex by normal appearing lung

(D) Line drawing of (C)

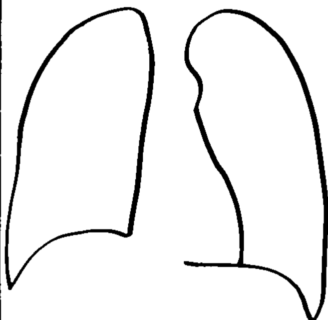
A



B







D

C

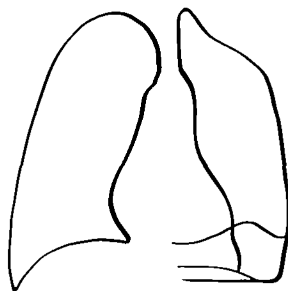
Fig 35 *Basal Pneumothorax*

(A) Posteroanterior film following resection of the apical posterior and anterior segments of the left upper lobe Preliminary to the resection, a three rib tailoring thoracoplasty had been performed This film was taken nine days following definitive surgery Resection of the 5th rib, through which the pulmonary resection was carried out is noted and the anterior stumps of the well tailored thoracoplasty can be recognized from ribs 2 and 3. This roentgenogram is presented for its good demonstration of a basal pneumothorax on the left, with an air fluid level extending across the entire left pleural cavity. Occasionally such air collections can be difficult to differentiate from subdiaphragmatic air In this case the diaphragm can be seen through the pneumothorax as well as the fundus of the stomach air collection beneath the diaphragmatic leaf The basal air collection was confirmed by aspiration of air and insertion of a catheter.

(B) Line drawing of (A).



A



B

Fig 36 *Basal and Anterior Pneumothorax*

(A) Posteroanterior film taken nine days postoperatively after a right upper lobectomy, as well as resection of the right middle lobe and superior division of the right lower lobe A previously performed tailoring thoracoplasty was extended to include the 4th and 5th ribs A large basal air collection and pleural fluid are seen

(B) Line drawing of (A)

(C) Lateral view of (A) showing the basal air fluid collection described as well as an anterior collection

(D) Line drawing of (C)


A
C


B
D

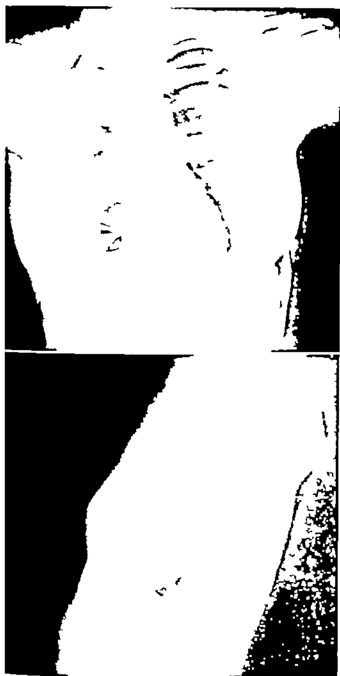
Fig 36 *Basal and Anterior Pneumothorax*

(A) Posteroanterior film taken nine days postoperatively after a right upper lobectomy, as well as resection of the right middle lobe and superior division of the right lower lobe. A previously performed tailoring thoracoplasty was extended to include the 4th and 5th ribs. A large basal air collection and pleural fluid are seen

(B) Line drawing of (A)

(C) Lateral view of (A) showing the basal air fluid collection described as well as an anterior collection

(D) Line drawing of (C)


A
C


B
D

Fig 37 *Basal Pneumothorax Anterior Pneumothorax*

(A) Posteroanterior film in a patient twelve days following resection of the right upper lobe when intervening films had appeared acceptable insofar as expansion and absence of residual pleural collections of air were concerned Either a spontaneous leak occurred subsequent to apparent complete expansion, or a small residual leak accumulated slowly during a silent period postoperatively and the present pneumothorax is seen largely at the right base, anteriorly and over the right apex An air fluid level at the right base extends across the entire pleural cavity. Prompt treatment of the air collection present with insertion of a catheter in the base resulted in prompt refilling of the chest by the remaining right lung

(B) Line drawing of (A).

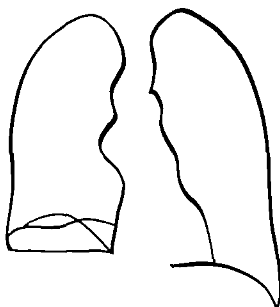
(C) Lateral view of (A)

(D) Line drawing of (C)

A

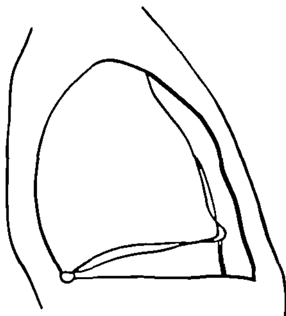


B





C



D

Fig 38 *Basal Pneumothorax Diaphragmatic Adhesions*

(A) Twenty-four hours after right upper lobectomy, with good re-expansion of the remaining right lung in this early post-operative stage A prominent "hilar" shadow is noted due to exudate Note drainage tube also present

(B) Line drawing of (A)

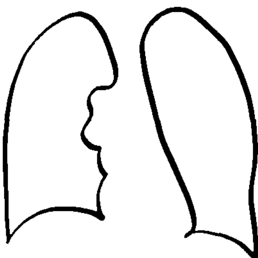
(C) Two days later, however, there is noted a basal pneumothorax as well as an apical collection of exudate. Prominent "hilus" is still in evidence

(D) Line drawing of (C)

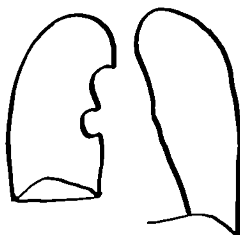
A



B







D

C

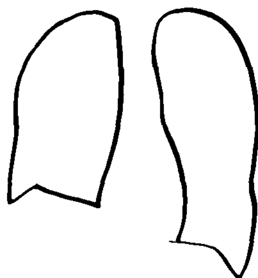
Fig 38—(*Continued*) *Basal Pneumothorax Diaphragmatic Adhesions*

(E) Six months later, reveals that the remaining right lung has expanded to fill the entire right pleural cavity There remains pleural change superiorly and at the base, where an adhesion is noted The right diaphragmatic leaf is slightly elevated as well as the right lung root The lung markings at the right base are slightly separated, presumably the result of expansion of the remaining right lung

(F) Line drawing of (E).



E



F

Fig 39 *Basal Pneumothorax Following Lower Lobe Resection*

(A) The early postoperative film reveals a basal pneumothorax on the right with a small amount of pleural fluid at the base of the pleural cavity This is normal after right lower lobectomy

(B) Line drawing of (A)

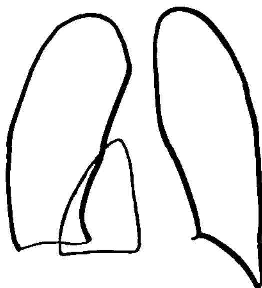
(C) Eight days later there is some replacement of air by fluid with multiple air fluid loculations now seen at the right base This course of events is normal One might also note that soft tissue swelling originally present at the operative site has now almost completely disappeared

(D) Line drawing of (C)

A

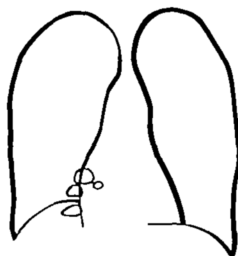


B





C



D

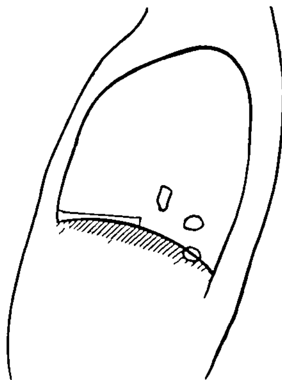
Fig 39 —(*Continued*) *Basal Pneumothorax Following Lower Lobe Resection*

(E) Lateral view

(F) Line drawing of (E)



E



F

Fig 40 *Basal Pneumothorax which May Simulate Free Subdiaphragmatic Air*

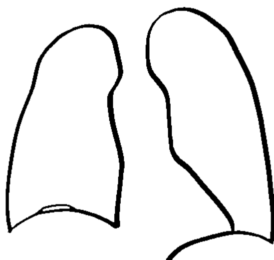
(A) Posteroanterior roentgenogram taken forty-eight hours after resection of the right upper and middle lobes This shows a satisfactory postoperative appearance with good expansion of the remaining right lung The particular finding of interest in this film is a small air collection at the right base which can simulate free subdiaphragmatic air but actually represents an early basal pneumothorax This is not an unusual finding in the early appearance of basal pneumothorax.

(B) Line drawing of (A)

(C) Four days later, the basal pneumothorax is much more apparent and easily identifiable

(D) Line drawing of (C).


A


B


C

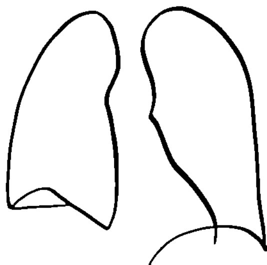

D

Fig 41. *Basal Pneumothorax after Paraffin Pack Thoracoplasty*

(A) A rather large, freshly placed, paraffin pack is seen over the upper portion of the right chest There was no known pleural injury at the time of placement of the pack nor was there evidence for abnormality in the immediate postoperative film The patient developed symptoms on the fourth postoperative day, consisting of shortness of breath and extensive collapse of lung tissue is noted in the presence of a large pneumothorax Spontaneous pneumothorax is the best explanation and again there is no clear etiology A catheter was inserted with prompt disappearance of the pneumothorax and re-expansion of the lung

(B) Line drawing of (A)

Fig. 42 *Hematoma of the Pleural Cavity*

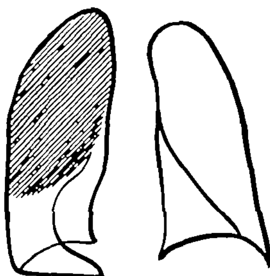
(A) Twenty-four hours after left pneumonectomy with apparent elevation of the left diaphragmatic leaf contour as evidenced by rather high stomach fundus air shadow An air fluid level extends across the left pleural cavity. Of particular interest is a somewhat triangular shaped density extending superiorly above the fluid level described We believe this most likely represents a clot adherent in the posterior gutter, due to the recumbent position of the patient in the immediate postopertaive period This allowed accumulation of clot or exudate in the posterior gutter where it became adherent

(B) Line drawing of (A)

A

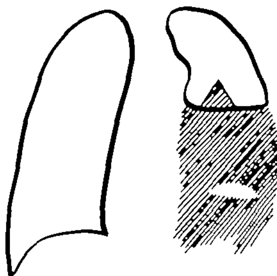


B





A



B

Fig 43. *Probable Hematoma, Pleural Cavity, Coughed Up Via Bronchus Indicating Presence of Bronchopleural Fistula*

(A) One week following surgery with resection of the right upper lobe A pleural cap is thought to be present which is a little more extensive than usually seen but not otherwise of interest

(B) Line drawing of (A)

(C) One week later there is clearing of the previously described superior opacity This is of interest because the patient coughed up dark bloody material during the interval and it is believed that this represented a collection of pleural blood which communicated with a small bronchus and was coughed up by the patient, indicating the presence of a bronchopleural fistula

(D) Line drawing of (C)

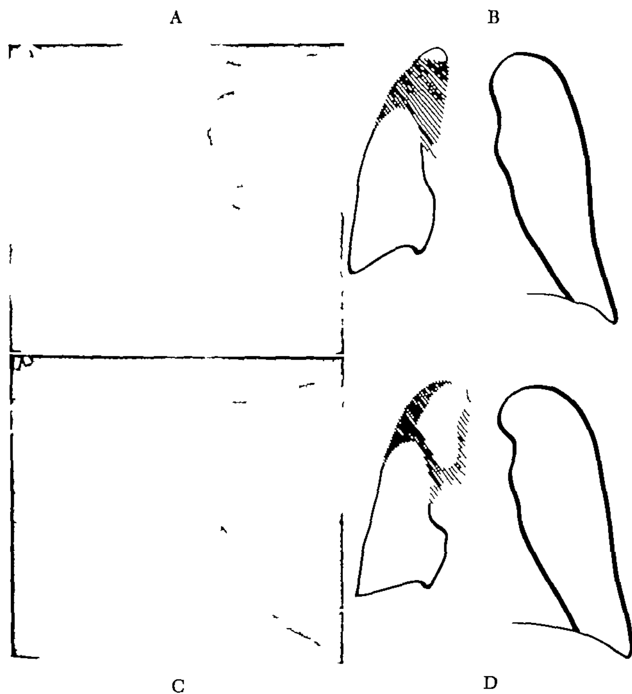

A
B
C
D

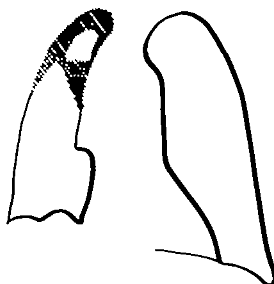
Fig 43.—(*Continued*) *Probable Hematoma, Pleural Cavity, Coughed Up Via Bronchus Indicating Presence of Bronchopleural Fistula.*

(E) Three days later, revealed slight resolution of the previously described findings The ultimate result was entirely satisfactory

(F) Line drawing of (E)



E



F

Fig 44 *Loculated Apical Hydropneumothorax after Right Upper Lobectomy and Rearrangement of Lobes*

(A) Early postoperative film in the posteroanterior projection reveals a loculated hydropneumothorax over the right apex which is an expected change

(B) Line drawing of (A)

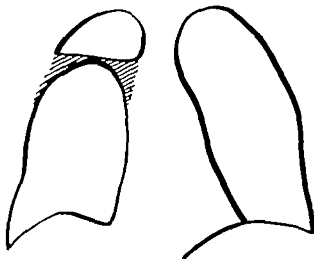
(C) The lateral view reveals the apical pneumothorax previously described as well as rearrangement of fissures The middle lobe is seen to be anterior to the long fissure and probably will occupy the apex of the pleural cavity The lower lobe is seen posterior to the long fissure Pleural exudate is seen, particularly anteriorly and superiorly.

(D) Line of drawing of (C)

A

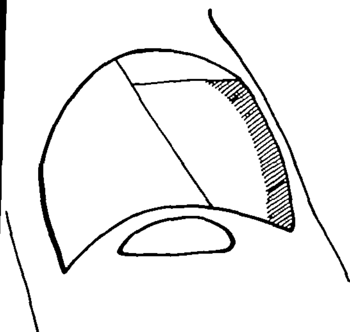


B





C



D

Fig 45 *Spacial Rearrangement of Lobes after Right Upper Lobectomy with Demonstration of an Accessory Fissure Separating the Apical and Subapical Portions of the Right Lower Lobe*

(A) Early postoperative appearance reveals an apical collection of air and fluid similar to those cases previously described.

(B) Line drawing of (A)

(C) Lateral view reveals a spacial rearrangement of lobes with the middle lobe seen anteriorly and the lower lobe posteriorly An accessory fissure is well demonstrated separating the apical and subapical portions of the lower lobe

(D) Line drawing of (C).

A

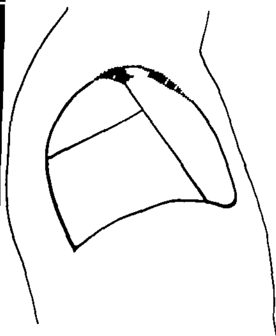


B





C



D

Fig 46 *Probable Lung Hematoma Following Bi-segmental Resection on the Left*

(A) This film shows an early postoperative result following bisegmental resection on the left, i e , the apical posterior segment of the left upper lobe and the superior division of the left lower lobe We believe that the opacity seen in the left upper lung field is best explained by hematoma along the segmental surface Pleural change in this region may also be present Complete resolution of this finding occurred in subsequent studies

(B) Line drawing of (A)

Fig 47 *Probable Hematoma of the Lung Following Resection of the Apical and Posterior Segments of the Right Upper Lobe*

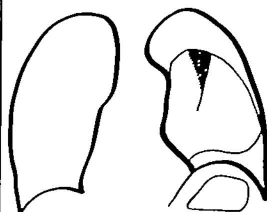
(A) Early postoperative film showing status after resection of the apical and posterior segments of the right upper lobe Pneumothorax is noted as well as consolidation superiorly, considered most likely the result of hematoma involving the remaining segment of the right upper lobe This process slowly cleared

(B) Line Drawing of (A)

A

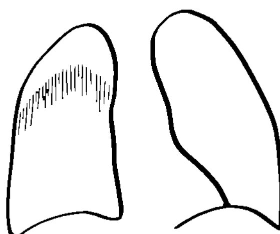


B





A



B

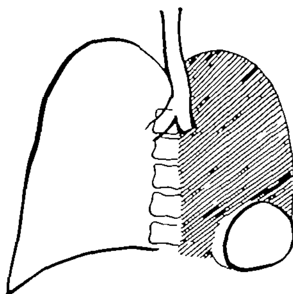
Fig 48 *Late Findings after Left Sided Pneumonectomy with Diminished Volume of the Left Pleural Cavity and Visualization of the Left Bronchial Stump*

(A) Reveals the postoperative result approximately seven months after pneumonectomy The changes seen illustrate the contraction in an empty hemithorax that becomes filled with exudate which organizes and contracts. The mediastinum is shifted toward the left and the left diaphragmatic leaf is considerably elevated The carina is easily recognized as well as most of the bronchial stump which is too long The tip of the bronchial stump is partially obscured. Narrowing of intercostal spaces, particularly superiorly, is also noted.

(B) Line drawing of (A).



A



B

Fig 49 *Lobar Rearrangement*

(A) Represents a film taken approximately ten months following resection of the right upper lobe and tip of the superior division of the lower lobe There is little evidence of remaining pleural reaction Rib regeneration is noted The mediastinum is in good position and the diaphragm shows minimal anterior elevation The right lung root appears slightly elevated The apex of the lower lobe is probably visualized in this study

(B) Line drawing of (A)

(C) A lateral view reveals the right middle lobe to occupy the apical and anterior portions of the right pleural cavity, whereas the lower lobe is seen posteriorly and inferiorly Laminography can also be utilized to good advantage for study of the redistribution of lobes and delineation of fissure lines

(D) Line drawing of (C)


A
C

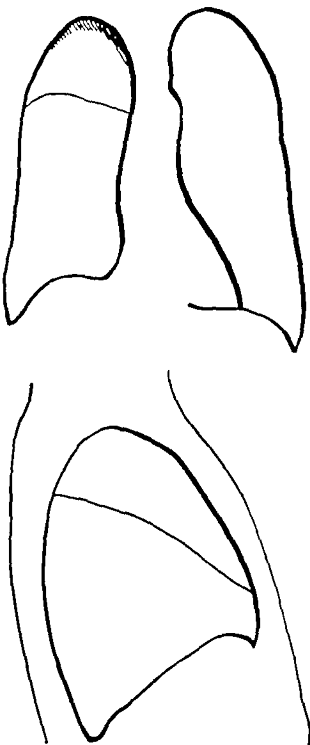

B
D

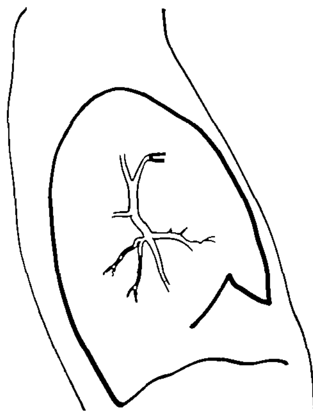
Fig. 49 (*Continued*) *Lobar Rearrangement*

(E) Lateral view bronchogram reveals the distribution of the main segmental bronchi in their rearrangement to good advantage

(F) Line drawing of (E)



E



F

Fig 50 *Rearrangement of the Right Upper Lobe and Right Middle Lobe Following Right Lower Lobectomy Questionable Atelectasis of Right Middle Lobe*

(A) Reveals a well demarcated thin-walled cystic space with an air fluid level inferiorly and medially overlying the right diaphragmatic leaf in part Evidence of previous rib resection and regeneration surrounding a tube-tract is also seen, along with absence of a portion of the 10th right rib This is a case of intrapulmonary sequestration with cystic changes A right lower lobectomy was carried out

(B) Line drawing of (A)

(C) Lateral view of (A).

(D) Line drawing of (C)

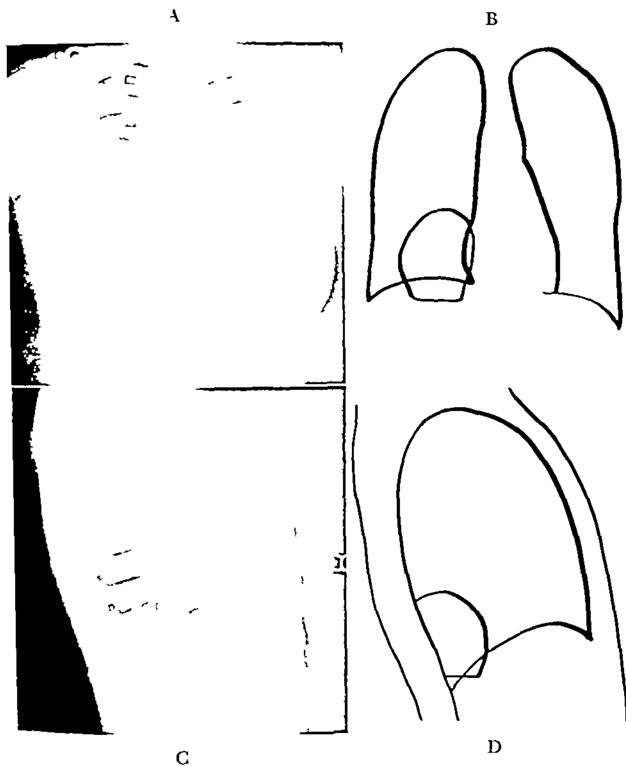

A
B
C
D

Fig. 50.—(*Continued*) *Rearrangement of the Right Upper Lobe and Right Middle Lobe Following Right Lower Lobectomy Questionable Atelectasis of Right Middle Lobe*

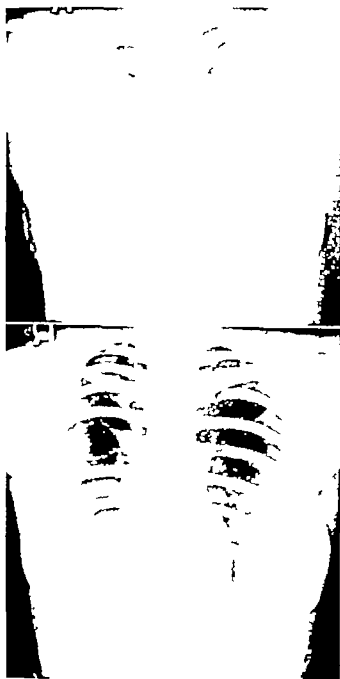
(E) Early postoperative film following right lower lobectomy in which there is some residual opacification at the right base with some pleural change in addition It is thought that the opacified area below a curving line over the right lower hemithorax represents a partially atelectatic right middle lobe which has dropped inferiorly to occupy some of the space of the gutter

(F) Line drawing of (E)

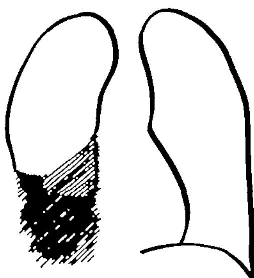
(G) Approximately two months later, reveals the opacified area to appear relatively normal in this examination with the curved line previously described faintly seen as the fissure between the middle and upper lobes Pleural change is also seen at the right base Lateral view of (E) fails to definitely visualize the fissure.

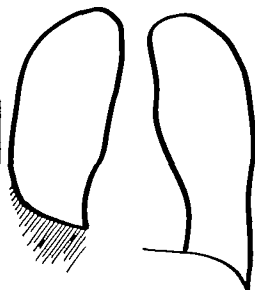
(H) Line drawing of (G)

E



F





H

G

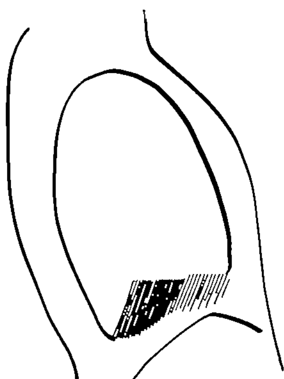
Fig. 50.—(*Continued*) *Rearrangement of the Right Upper Lobe and Right Middle Lobe Following Right Lower Lobectomy Questionable Atelectasis of Right Middle Lobe*

(I) Lateral view of (G) fails definitely to visualize the fissure between the upper and middle lobes.

(J) Line drawing of (I)



I



J

Fig 51 *Rearrangement of Lobes Apical Air Collection*

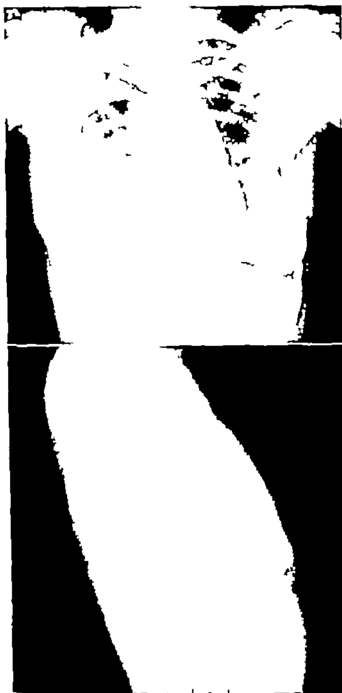
(A) Posteroanterior film in an early stage following right upper lobectomy preceded by a tailoring thoracoplasty. This film shows a relatively well re-expanded lung but there still is an apical space in the gutter posteriorly under the collapse of the tailoring thoracoplasty A faint fluid level is seen Minimal subcutaneous emphysema is noted as well as minimal pleural changes at the right base

(B) Line drawing of (A)

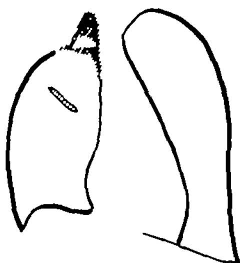
(C) Lateral view of (A) This film shows nicely the rearrangement of lobes following a right upper lobectomy and resection of the tip of the superior division of the lower lobe Two fissures can be recognized in this lateral view, one representing a fissure of the left side and the other representing the fissure on the right side The middle lobe is seen to occupy the area anterior and superior to the fissure and the lower lobe the basal and posterior sections An apical air fluid collection is also seen

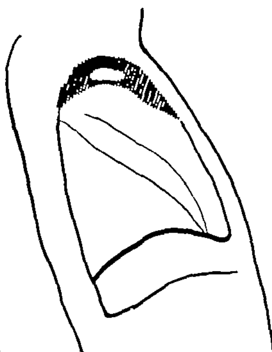
(D) Line drawing of (C)

A



B





C

D

Fig 52 *Redistribution of Lobes after Right Upper Lobectomy.*

(A) Reveals opacification of the right apex by a pleural collection in this region after right upper lobectomy Minimal pleural change is seen at the right base. The apices of the lower and middle lobes are covered by pleural exudate and are visible in the posteroanterior projection

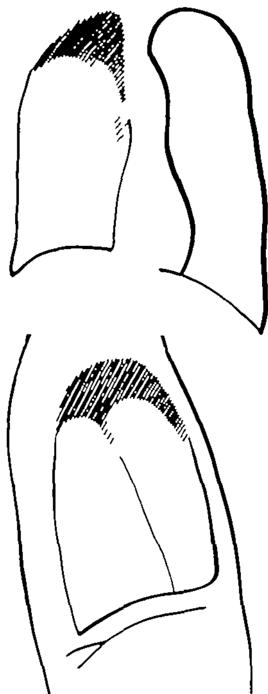
(B) Line drawing of (A).

(C) Reveals the apical collection of pleural exudate previously described which dips into the long fissure. Thus the middle lobe is seen to lie anteriorly and the lower lobe posteriorly. The apices of both these lobes are seen to be covered by pleural exudate and are clearly visible in this study.

(D) Line drawing of (C)

A B



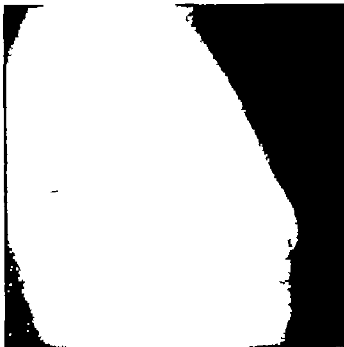


C D

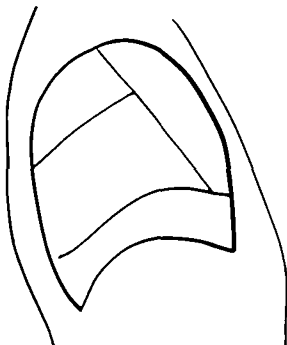
Fig 53 *Redistribution of Lobes Following Right Upper Lobectomy Accessory Fissure*

(A) Reveals a lateral view, post-right upper lobectomy, in which the redistribution of lobes postoperatively is seen to good advantage with the middle lobe anteriorly and the lower lobe posteriorly An oblique line running across the spine from the gutter toward the fissure between the lower and middle lobes is of interest. This patient had a partial separation of the superior division from the remaining portion of the lower lobe with an incomplete fissure which is seen to good advantage in the available radiograph

(B) Line drawing of (A)



A



B

Fig 54 *Rearrangement Following Left Upper Lobectomy. Demonstration of Lingula*

(A) Early postoperative film after resection of the apical posterior and anterior divisions of the left upper lobe Pleural reaction in the left infra-clavicular zone is sharply marginated inferiorly and is seen to outline the lingular segment, left upper lobe Minimal pleural change is also seen at the left base.

(B) Line drawing of (A)

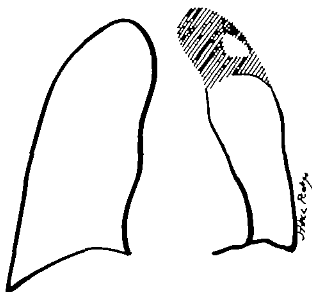
(C) Lateral view reveals the lingular segment of the left upper lobe anterior to the long fissure level The lingula is seen anterior to the fissure level and the lower lobe posterior to the fissure level The lingula is covered by pleural exudate

(D) Line drawing of (C)

A

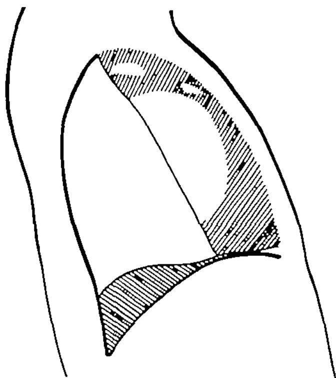


B





C



D

Fig 54—(*Continued*). *Rearrangement Following Left Upper Lobectomy Demonstration of Lingula*

(E) Diminished pleural change is seen in an examination five months later The postoperative film is satisfactory with no evidence for complication Minimal pleural change remains.

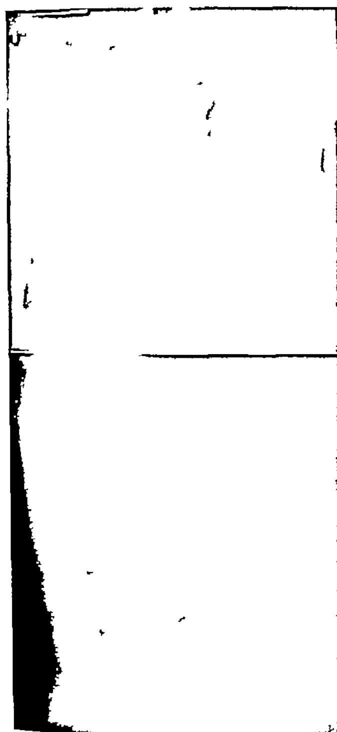
(F) Line drawing of (E).

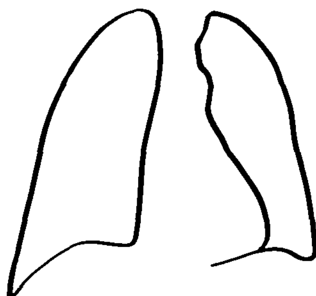
(G) Lateral view of (E) with minimal pleural changes remaining and further expansion of the lingular segment of the left upper lobe

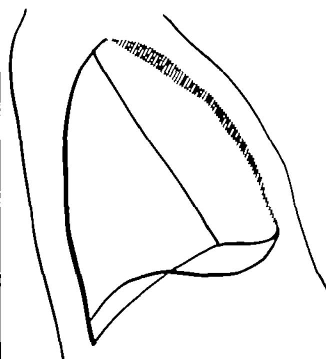
(H) Line drawing of (G)

E

F







G

H

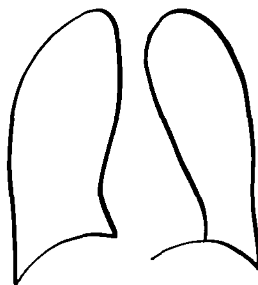
Fig 55—(*Continued*) *Rearrangement Following Resection of Anterior and Lingular Segments of the Left Upper Lobe*

(E) The postoperative appearance approximately ten months later with no complications Fissure lines are not identified.

(F) Line drawing of (E)



E



F

Fig. 56 *Lung Herniation, Post-pneumonectomy*

(A) Reveals good demonstration of a mediastinal hernia of localized source, post-pneumonectomy Some years previously, in Japan, this woman had undergone a thoracoplasty of columnar type A pneumonectomy was subsequently performed in this country. Herniated lung is well demonstrated overlying the upper dorsal spine and extending toward the left pleural cavity.

(B) Line drawing of (A)

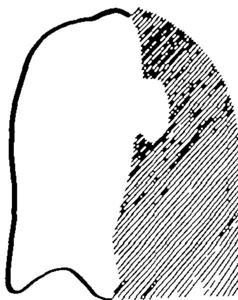
(C) Lateral view of (A), showing the anterior location of the lung herniation described

(D) Line drawing of (C)

A

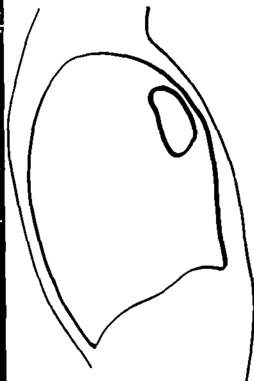


B





C



D

Fig 56—(*Continued*) *Lung Herniation, Post-pneumonectomy*

(E) Approximately seven months later, reveals progression with enlargement of the previously described mediastinal hernia extending toward the left pleural cavity. There has been further shrinkage of the left chest with further retraction of the mediastinum toward the left

(F) Line drawing of (E)

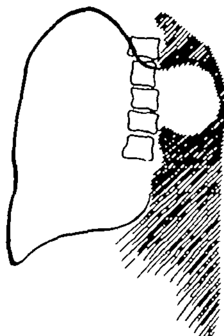
(G) Lateral view, shows the progression and enlargement of the lung herniation described above, which now extends toward the posterior mediastinum in addition.

(H) Line drawing of (G)

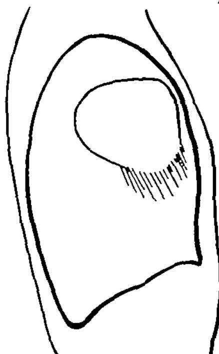
E

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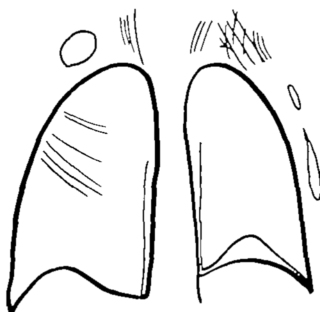
Fig 57 *Excess Air in the Soft Tissues*

(A) Extensive subcutaneous, intramuscular and mediastinal emphysema In this case, the cause of extensive emphysema was undetermined clinically Nevertheless the emphysema was considered a complication and did cause some concern. One will note that there is mediastinal emphysema which can be followed through the neck soft tissues Fasciculations of the pectoralis major muscle are also well demonstrated

(B) Line drawing of (A).



A



B

Fig 58 *Excess Air in the Soft Tissues and Mediastinal Emphysema*

(A) Early postoperative film showing an extensive subcutaneous, intramuscular and mediastinal emphysema This was considered a complicating emphysema because of the nature of the surgery performed This patient originally had all of her right lung removed with the exception of the basal segments of the right lower lobe and this was done with an extensive thoracoplasty However, a complicating small empyema with a large bronchial fistula resulted During a subsequent surgical procedure the empyema was drained and during exposure of the empyema, tissue planes which had been sealed by previous surgery were opened As a result, a large volume of air coming from the bronchial fistula was then dissipated into fresh tissues and presented this picture of extensive emphysema The emphysema is noted to dissect, separating the subcutaneous and fascial planes along the chest wall Considerable mediastinal emphysema is also noted

(B) Line drawing of (A)

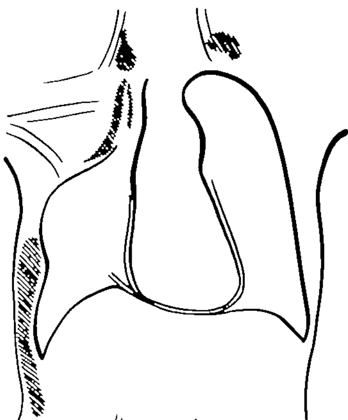
(C) One day later

(D) Line drawing of (C)

A

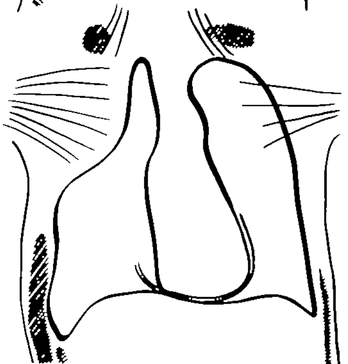


B





C



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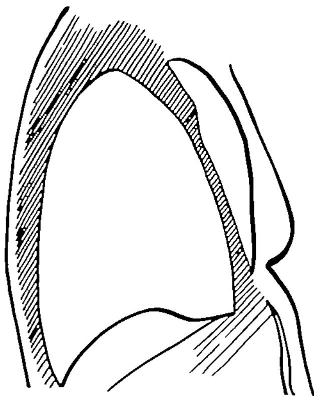
Fig 58—(*Continued*) *Excess Air in the Soft Tissues and Mediastinal Emphysema*

(E) Lateral view

(F) Line drawing of (E)



E



F

Fig 59 *Chronic Apical Pneumothorax*

(A) Early postoperative film after resection of the right upper lobe with an apical air fluid collection within normal limits for the early postoperative period

(B) Line drawing of (A)

(C) Approximately two and one-half months later, reveals a residual pneumothorax over the right apex with no un-unusual or increasing fluid collections in this region. This space is too high to effectively needle to determine whether or not there is positive pressure It is assumed that this air space represents a chronic pneumothorax without complications It is believed that this merely represents incomplete expansion of the lower and middle lobes to occupy the apical region of the right pleural cavity

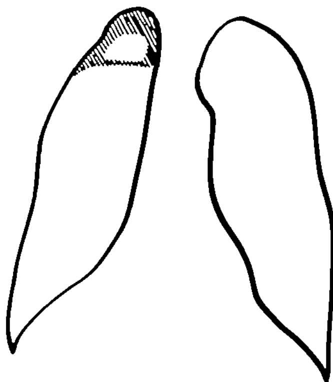
(D) Line drawing of (C)

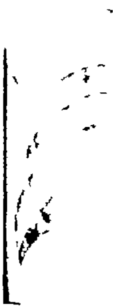
A



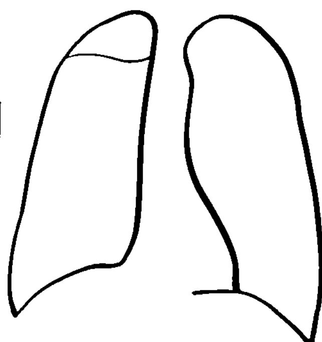


B









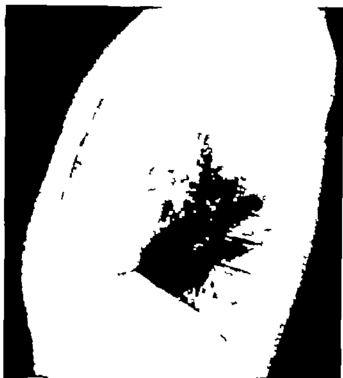
C

D

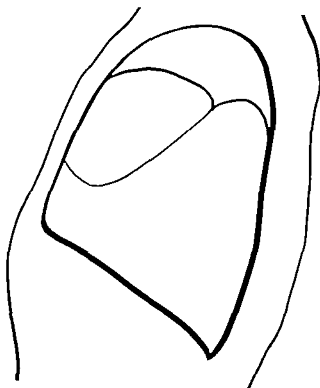
Fig 59—(*Continued*) *Chronic Apical Pneumothorax*

(E) Lateral view of (C), showing apical pneumothorax and redistribution of the middle and lower lobes

(F) Line drawing of (E)



E



F

Fig 60 *Chronic Pneumothorax after Decortication and Right Upper Lobectomy*

(A) Film following decortication of a basal empyema which yielded a pure culture of pyocyaneus Considerable lung was salvaged, but a small and completely carnified right upper lobe was resected at the same time The remaining lung, being considerably fibrosed, refused to occupy the entire space, thus leaving an apical pneumothorax The patient's clinical course, however, was excellent

(B) Line drawing of (A)

(C) Taken eleven months later, reveals that the superior pleural cavity air has been replaced by organized exudate This is an example of a lung that has undergone sufficient insult to be unable to expand, even to fill a contracted hemithorax, but with present antibiotic management, the situation is compatible with ultimate good results as occurred in this case.

(D) Line drawing of (C)

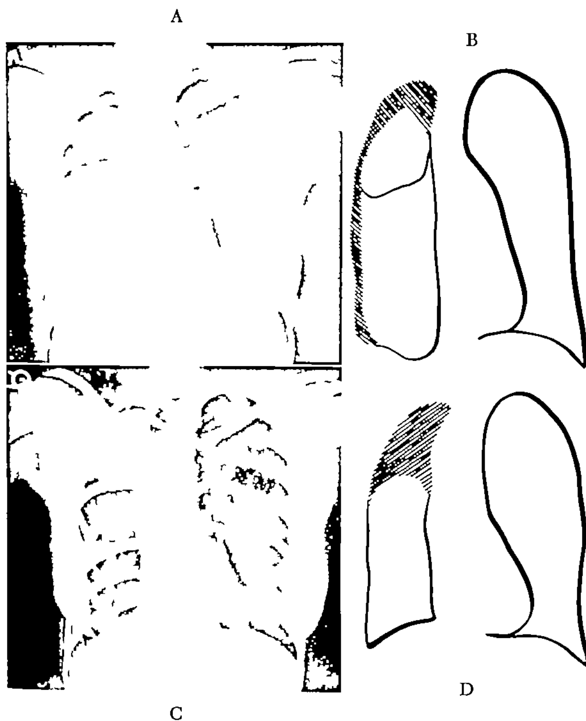

A
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Fig 61 *Pneumothorax Complicating Resection Slow Absorption*

(A) Early film following resection of the right upper and middle lobes This film was taken twenty-four hours after resection Findings are not unusual for the early postoperative stage, and there is a small pneumothorax over the apical zone

(B) Line drawing of (A)

(C) Three days later, reveals the lower lobe to have expanded to fill the right pleural cavity essentially There is questionable evidence for pneumothorax in the apex. Drainage tubes were removed, since they ceased to function.

(D) Line drawings of (C)

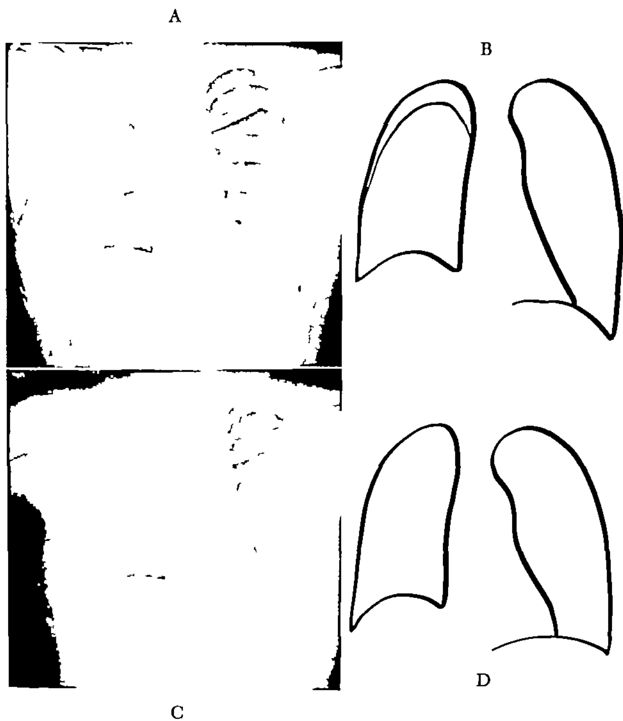

A
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Fig 61—(*Continued*) *Pneumothorax Complicating Resection Slow Absorption*

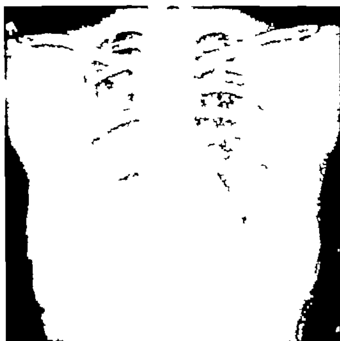
(E) Three days later, reveals very definite general pneumothorax seen over the apex, laterally and at the base. This situation occurs in lobes that are relatively small when they are asked to fill an entire hemithorax, particularly if they have been the seat of former disease, and therefore are influenced by a certain degree of fibrosis It is believed that this is probably explained on the basis of elastic recoil, and that seepage of air from minute bronchial leaks or possibly from disruption of the visceral pleura spontaneously at some point accounts for the presence of the air described. Institution of aspiration or replacement of the drainage tube will generally restore the lung to its former state, and eventually this will fill the pleural cavity quite adequately. This case was managed by aspiration It will be incidentally noted that the right diaphragmatic leaf, which is not paralyzed, has become elevated to help reduce the volume of the right pleural cavity

(F) Line drawing of (E).

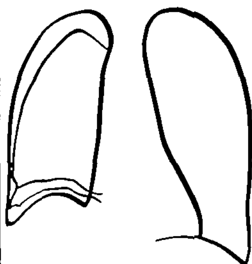
(G) Lateral view of (E)

(H) Line drawing of (G)

E

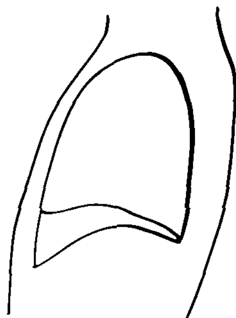


F





G



H

Fig 61—(*Continued*) *Pneumothorax Complicating Resection Slow Absorption*

(I) Approximately one year later, reveals an excellent postoperative appearance with the lower lobe on the right side expanding to fill the right pleural cavity The right diaphragmatic leaf is elevated There are no complications

(J) Line drawing of (I).

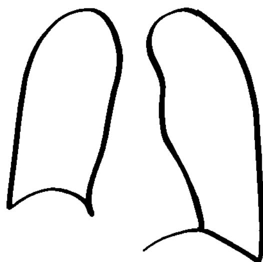
(K) Lateral view of (I)

(L) Line drawing of (K).

I

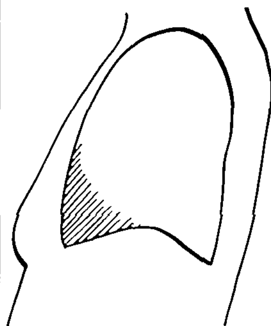


J





K



L

Fig 62 *Chronic Apical Pneumothorax*

(A) Reveals a persistent apical pneumothorax which resisted all forms of management, including re-exploration The amount of lung resected initially was the apical and posterior segments of the right upper lobe Explanation of the pneumothorax is not known

(B) Line drawing of (A)

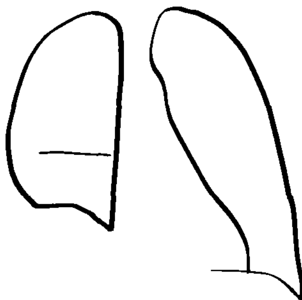
(C) Lateral view of same reveals the remaining right lung to be situated inferiorly and posteriorly in the pleural cavity Pneumothorax is seen over the apical zone and anteriorly

(D) Line drawing of (C)

A

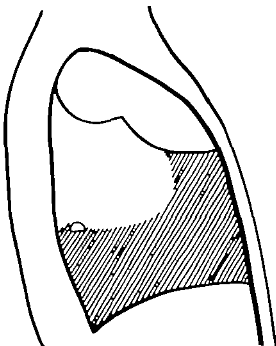


B





C



D

Fig 62 *Chronic Apical Pneumothorax*

(A) Reveals a persistent apical pneumothorax which resisted all forms of management, including re-exploration The amount of lung resected initially was the apical and posterior segments of the right upper lobe Explanation of the pneumothorax is not known

(B) Line drawing of (A)

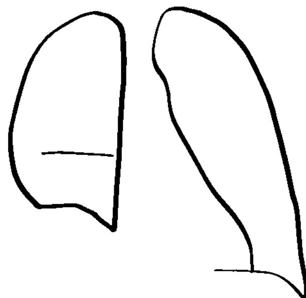
(C) Lateral view of same reveals the remaining right lung to be situated inferiorly and posteriorly in the pleural cavity Pneumothorax is seen over the apical zone and anteriorly

(D) Line drawing of (C)

A

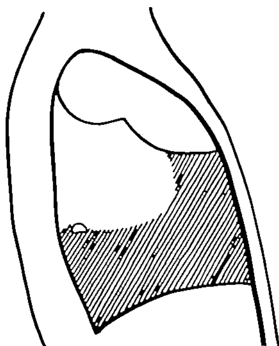


B





C



D

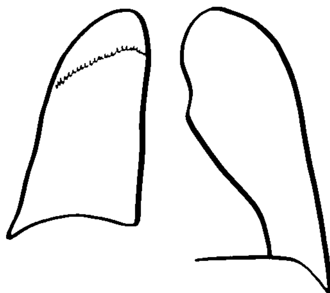
Fig 62—(*Continued*) *Chronic Apical Pneumothorax*

(E) Six months later, reveals that a gradual re-expansion of the right lung has occurred, but that an apical pneumothorax persists No complication is otherwise noted

(F) Line drawing of (E).



E



F

Fig 63. *Postoperative Pneumothorax*

(A) Reveals evidence for extensive subcutaneous emphysema involving the neck and pectoral folds, as well as extensive loculated pneumothorax on the left following resection of the apical posterior segment of the left upper lobe and superior division of the left lower lobe Multiple fluid levels can be seen within the left hemithorax, including a large basal air collection on this side

(B) Line drawing of (A)

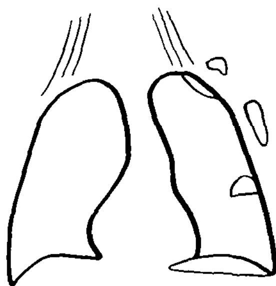
(C) Approximately nine days later, shows considerable improvement in expansion of the left lung, which now almost fills the left plueral cavity The dome of the lung rises above the clavicular level Elevation of the left diaphragmatic leaf is noted. This is a compensatory effect

(D) Line drawing of (C)

A

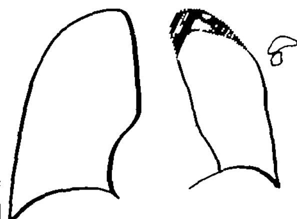


B





C



D

Fig 63—(*Continued*) *Postoperative Pneumothorax.*

(E) Approximately ten weeks later, shows a recurrence of pneumothorax at the left base, clearly outlining the inferior aspect of the remaining left lung The reason for this leak is not established, but it required repeated observations, with aspiration and insertion of intercosal catheters No complications ensued in spite of annoying recurrence of the air leak No explanation for the recurrence was evident Nevertheless, it shows that when properly managed, chronic pneumothoraces may persist for considerable periods of time without the development of important complications

(F) Line drawing of (E)

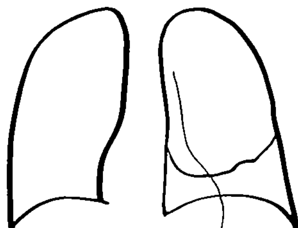
(G) Approximately six months after the last film, reveals complete re-expansion of the remaining left lung with no evidence for complications and the postoperative appearance is quite satisfactory

(H) Line drawing of (G)

E

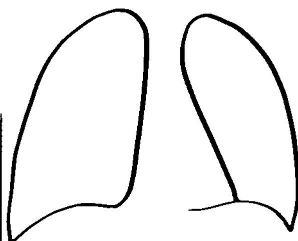


F





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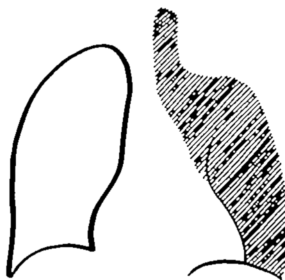
Fig 64 *Hemothorax*

(A) This film illustrates an early postoperative examination following resection of the left upper lobe and decortication of infolding pleural adhesions and peel This operation has been preceded by a tailoring type of thoracoplasty Considerable opacity is seen in the left hemithorax and this opacity is believed to be due to bloody exudate since postoperatively this patient bled not only after the definitive surgery, but also following the thoracoplasty procedure. No cause for this abnormal bleeding could be found, but it was compensated for and no ultimate complication ensued. One of the causes of extensive pleural opacification or hemithorax opacification at an early postoperative stage is bleeding into the pleural cavity or overlying soft tissues

(B) Line drawing of (A)



A



B

Fig 65. *Bleeding into the Pleural Cavity Bleeding into the Soft Tissues in the Surgical Field*

(A) This film shows an immediate postoperative appearance following a tailoring thoracoplasty on the left with removal of three ribs. One will note that there is a marked increase in the size of the soft tissues about the left shoulder and along the left lateral thoracic cage. This is due to hemorrhagic extravasation in the soft tissues as a result of the operative procedure

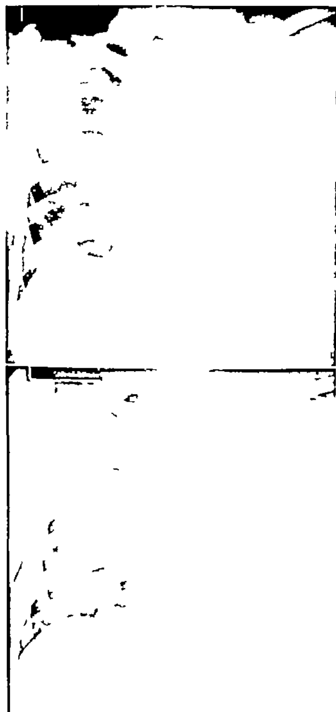
(B) Line drawing of (A)

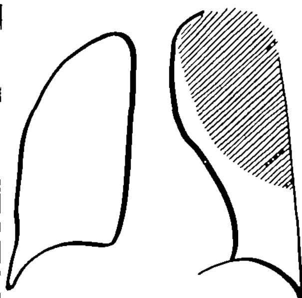
(C) Depicts the findings two months later following a left upper lobectomy and opacification of the left hemithorax. During the procedure pleural adhesions were freed and this amounted to a decortication Immediately following the procedure the patient bled into the pleural cavity, as evidenced by a considerable outpouring of blood from his drainage tubes There was no clear explanation for the bleeding, which occurred following each operative procedure The possibility of an unrecognized hemorrhagic diathesis, with which the patient might be afflicted, should be considered Gradual resolution of the described processes occurred and (E) represents a radiograph taken approximately three and one-half months later

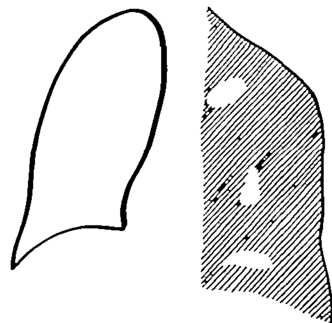
(D) and (F) Line drawings of (C) and (E)

A

B







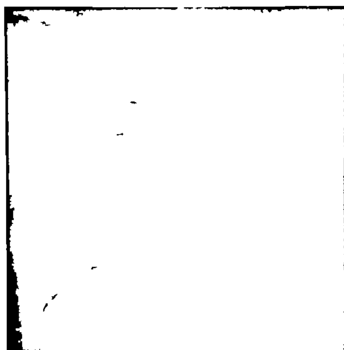
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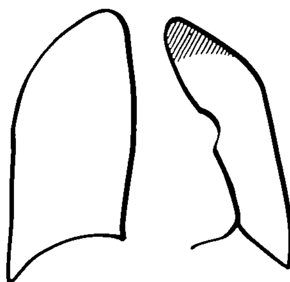
Fig 65. (*Continued*). *Bleeding into the Pleural Cavity. Bleeding into the Soft Tissues in the Surgical Field*

(E) Radiograph taken three and one-half months later

(F) Line drawing of (E)



E



F

Fig 66 *Chronic Subscapular Air Space. Empyema*

(A) Three months postoperatively, demonstrates a right subscapular air collection The subscapular space communicated with the bronchus This was proved when external drainage was performed

(B) Line drawing of (A)

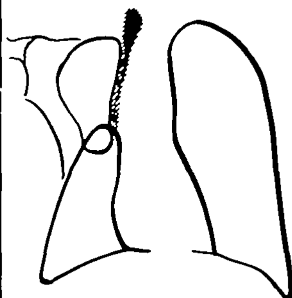
(C) Approximately six months later, demonstrates a smaller but very definite subscapular air pocket, presumably also communicating with the bronchus

(D) Line drawing of (C)

A

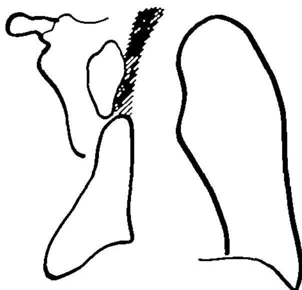


B





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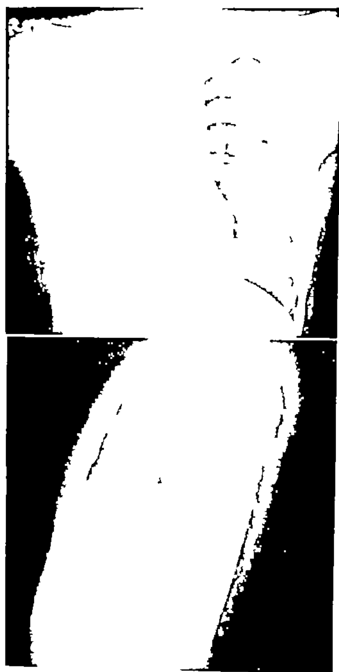
Fig 67 *Empyema Following a Right Upper Lobectomy*

(A) Shows the chest approximately three weeks following a right upper lobe resection This patient's lung failed to rise to the dome of the pleura and the apical space filled with exudate, which can be seen as a loculation in this instance The lateral film discloses the relationship of the right middle lobe lying anteriorly and extending up into this cap of exudate The right lower lobe lying posteriorly, behaving in a somewhat similar fashion in extending with its apex to the exudate and its lower portion down to the pleural base. Aspiration of the space showed the fluid to be infected There was no gross pus, but the bloody fluid which was obtained contained a staphylococcus

(B) Line drawing of (A)

(C) A lateral view of radiograph (A)

(D) Line drawing of (C)


A
C

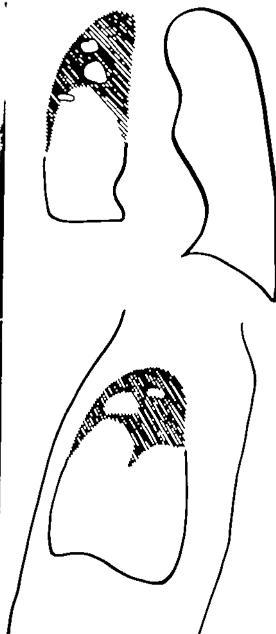

B
D

Fig 68 *Mottled Appearance of Empyema Content*

(A) Postoperative film following a pleuro-pneumonectomy for destroyed lung and overlying empyema The striking feature is the mottled appearance of the contents of the left hemithorax Because the usual uniform shadow of fibrinous fluid is not present, it raises the possibility that there might be a purulent process in the left pleural cavity This was true in spite of the retraction of the mediastinum toward the operative side

(B) Line drawing of (A).



A



B

Fig 69 *Sinus Tract with Fistula to Pleura.*

(A) Demonstrates a pleuro-cutaneous fistula which developed in an infected incision Lipiodol® was injected along the inferior aspect of the incision It coursed upward and posteriorly to the upper portion of the incision, where it collected in a small pool The fact that lipiodol has entered the pleural cavity is well demonstrated by the beaded appearance of the lipiodol which is mixed with empyema fluid In the anteroposterior view one notes a mottled radiolucence in the mid-portion of the left hemithorax This represents small air loculations within the empyema pocket

(B) Line drawing of (A)

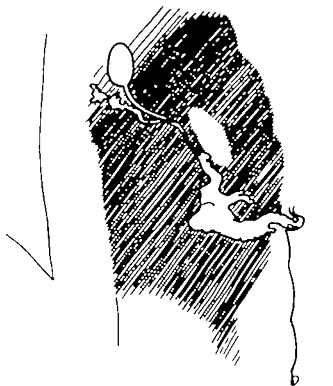
(C) Lateral view of (A).

(D) Line drawing of (C)

A

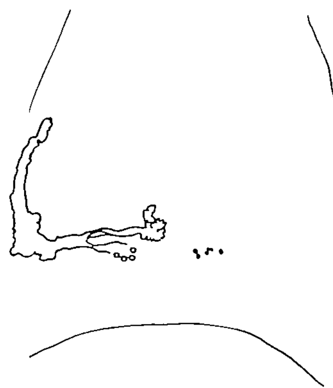


B





C



D

Fig 69 *Sinus Tract with Fistula to Pleura*

(A) Demonstrates a pleuro-cutaneous fistula which developed in an infected incision Lipiodol® was injected along the inferior aspect of the incision It coursed upward and posteriorly to the upper portion of the incision, where it collected in a small pool The fact that lipiodol has entered the pleural cavity is well demonstrated by the beaded appearance of the lipiodol which is mixed with empyema fluid. In the anteroposterior view one notes a mottled radiolucence in the mid-portion of the left hemithorax. This represents small air loculations within the empyema pocket.

(B) Line drawing of (A)

(C) Lateral view of (A)

(D) Line drawing of (C)

A

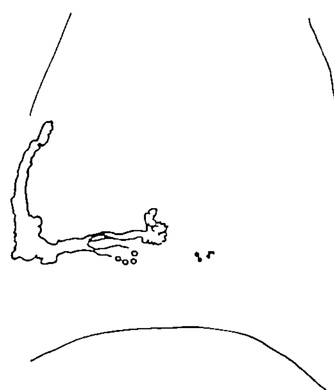


B





C



D

Fig 70. *Incision Infection with Empyema*

(A) The postoperative film after left upper lobectomy reveals no unusual findings Some soft tissue air collections are noted as well as small air fluid loculations in the left pleural cavity with minimal pleural change. These findings are not unusual

(B) Line drawing of (A)

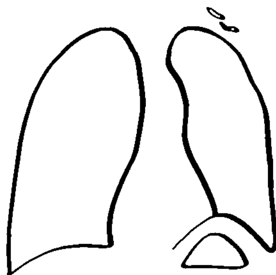
(C) Approximately seven days later, now reveals lobulated masses along the superior and lateral aspects of the left hemithorax These masses were due to infected hematoma along the rib bed, the areas of infection being in communication with the pleural cavity and giving rise to intra-pleural empyema The area of increased density in the base of the left pleural cavity is actually a subpulmonary (supra-diaphragmatic) collection of pus The stomach bubble is seen in the usual location in this study (confirmed with barium) Progressive increased density in a surgical area after several days of gradual resolution of normal postoperative changes is considered most likely the result of empyema

(D) Line drawing of (C)

A

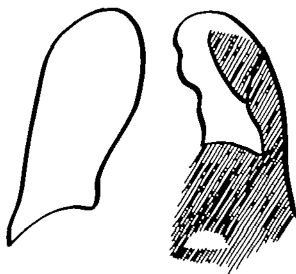


B





C



D

Fig 71 *Empyema Bronchopleural Fistula*

(A) This patient had had a resection of the right upper lobe, right middle lobe, and superior division of the right lower lobe, along with a 5-rib thoracoplasty. This procedure was carried out five years prior to this film Following this procedure the sputum had been persistently positive[*] and, as noted in the region of the 6th and 7th ribs posteriorly, there is a persistent pleural shadow which suggests very strongly the presence of a persistent pleural reaction or infection Surgery following this first film revealed an empyema within the space immediately above the remaining basilar segments The basal segments have failed to fill "the apex" of the reduced hemithorax and this empyema pocket, although small, communicated freely with the bronchus of the superior division of the right lower lobe No level of fluid or air can be recognized because of the small size of this space However, the persistence of a heavy pleural reaction is caused by the continued active process in the pleura

(B) Line drawing of (A)

(C) Shows the presence of air in the subscapular space. This air is in the subscapular space because of a drain communicating with the pleural cavity which harbors a pneumothorax

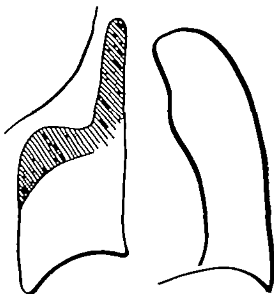
(D) Line drawing of (C).

[*] Mycobacterium tuberculosis

A

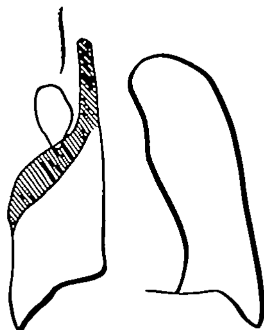


B





C



D

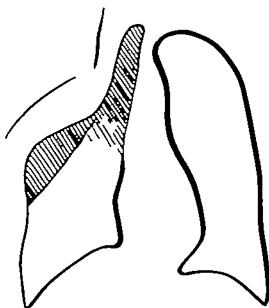
Fig. 71 —(*Continued*) *Empyema Bronchopleural Fistula.*

(E) Shows the later postoperative appearance in which the subscapular air has been resorbed and there is no longer a pneumothorax within the reduced right hemithorax

(F) Line drawing of (E)



E



F

Fig 72 *Empyema*

(A) Chest radiograph taken approximately two weeks following surgical resection of the apical posterior segment of the left upper lobe for post-tuberculous bronchiectasis At operation it was noted that the lung was exceedingly emphysematous and large air leaks delayed the re-expansion of this lung As noted, there is still evidence for subcutaneous emphysema bilaterally Retained Lipiodol® is noted in each lung field A loculation of fluid and air can be seen overlying the left hilar zone This film particularly reveals the presence of a large space in the upper lateral aspect of the left hemithorax This space represents the extent to which the lung could be expanded initially, and therefore represents an empyema space, because it communicates freely with the outside through a tube The presence of the tube in this space is not seen clearly

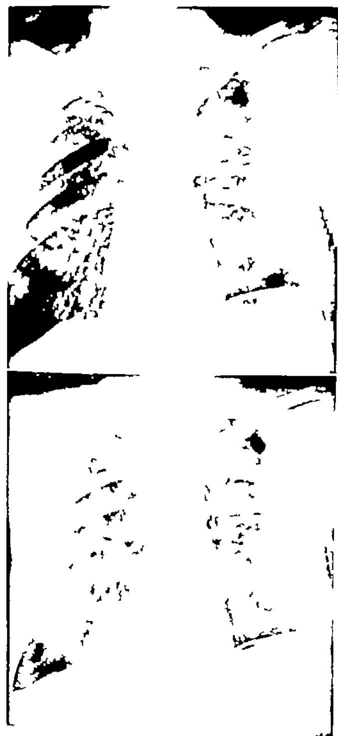
(B) Line drawing of (A)

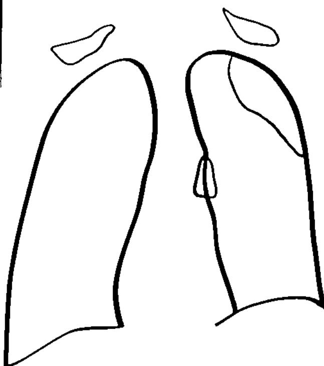
(C) Radiograph taken approximately three days later shows a reduction in the size of the empyema space However, at this time there is also a small accumulation of fluid in the dependent portion of the space The catheter which had been draining this space had slipped from a satisfactory position to a point outside the pleura, therefore, it was no longer effective

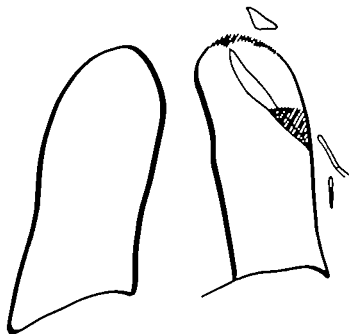
(D) Line drawing of (C)

A

B







C

D

Fig 72 —(*Continued*) *Empyema*

(E) Taken two months after (C) shows further progress in the healing of the empyema space The space is now much smaller and the catheter is evacuating and draining the space adequately

(F) Line drawing of (E)

(G) Taken ten weeks after resection shows the space to be obliterated and there is a fading residual pleural shadow which will disappear ultimately

(H) Line drawing of (G)


E
G

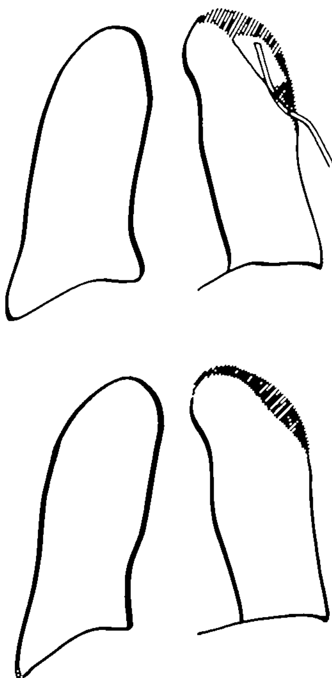

F
H

Fig 73 *Empyema*

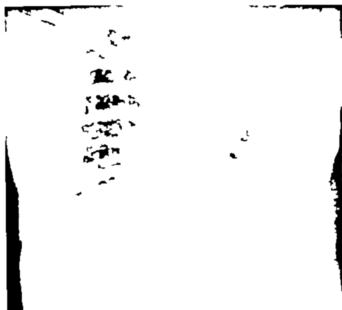
(A) Approximately three weeks following surgical resection of the apical posterior segment and the anterior segment of the left upper lobe One will note that there appears to be relatively satisfactory expansion of the remaining portions of the lungs to fill the left hemithorax There is, however, a suggestion that the apex is more radiolucent than the remainder of the left lung field The lateral radiograph confirms the presence of air anterior to the partially expanded lung. This would comprise a loculated anterior pneumothorax in the left upper hemithorax

(B) Line drawing of (A)

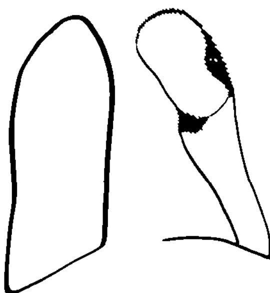
(C) Approximately one week later, and shows the appearance of the previously suspected pneumothorax to better advantage The left lower lobe has expanded to fill the apical zone posteriorly, but anteriorly there is an air fluid level and this is noted underlying the second anterior rib interspace This would indicate roughly the dimensions of this air space

(D) Line drawing of (C)

A

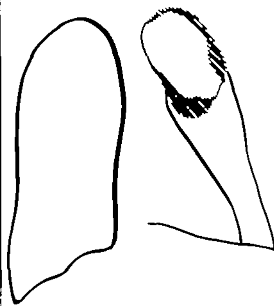


B





C



D

Fig 73—(*Continued*) *Empyema*

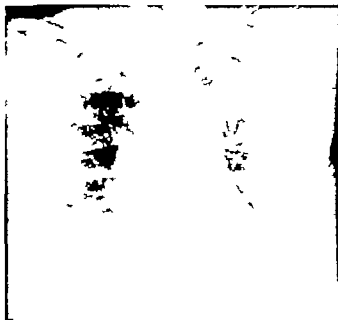
(E) Approximately two months following resection. One will note a smaller space, but the fluid level has increased and become more apparent There had been no indications clinically or otherwise until this time that the space harbored an empyema. However, at this time the sputum became positive and it was believed that a bronchial communication was present On this premise, a diagnosis of mixed tuberculous and pyogenic empyema was made as a complication to recent surgery Drainage of the space was carried out

(F) Line drawing of (E)

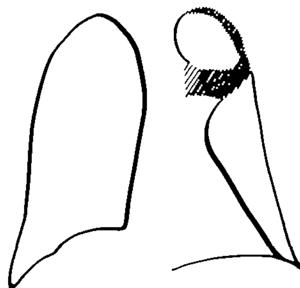
(G) Lateral film of (E)

(H) Line drawing of (G)

E

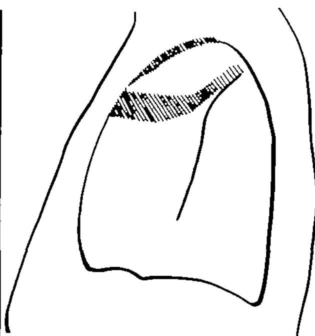


F





G



H

Fig 73—(*Continued*) *Empyema*

(I) Eight weeks after the empyema cavity was drained At this time a tube tract is noted, extending into the previously described space, the space is much smaller, and there is much more aeration of the left lung than previously At this time the sputum was no longer positive for tuberculosis bacteria

(J) Line drawing of (I)

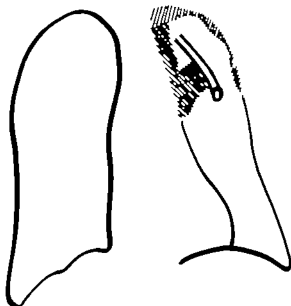
(K) Approximately six months after the resection, shows further improvement in the appearance of the left upper lung zone. Lipiodol® was instilled into the tract The Lipiodol® is noted in granulation tissue in a very small tract (no larger than the actual drainage tube)

(L) Line drawing of (K)

I



J



L

K

Fig 74 *Bronchopleural Fistula*

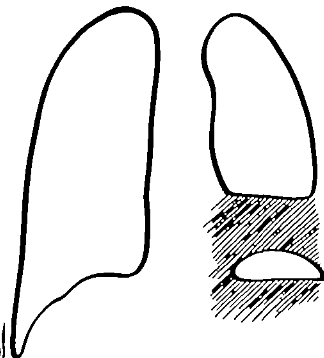
(A) Film taken two months following pneumonectomy Note the hydropneumothorax on the left side, the mediastinum in the midline and apparent slight elevation of the left leaf of the diaphragm Since this is two months following pneumonectomy, one would expect that the left pleural space would be better filled; and there would be a usual shift of the mediastinum towards the left and somewhat overdistention of the remaining right lung Consequently, one must suspect, on the basis of this radiograph, that there is probably a bronchopleural fistula present Since the air fluid level is at a relatively low point, one must assume that the pleural space has been constantly evacuated *via* the bronchus Note also the patches of infiltration which are not too clearly defined throughout the right lung This probably represents aspirated material incidental to the left bronchopleural fistula Clearing of the right sided infiltration occurred without further complications after drainage of the left empyema

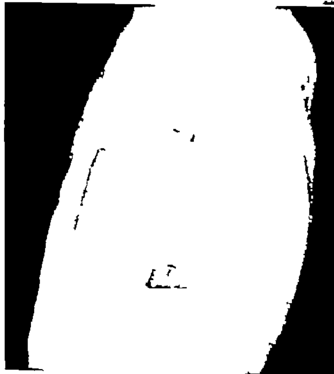
(B) Line drawing of (A)

(C) Lateral view of (A)

(D) Line drawing of (C)


A


B


C

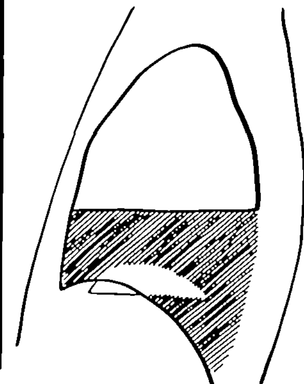

D

Fig 75 *Infected Prosthesis Drained and Showing an Air Fluid Level.*

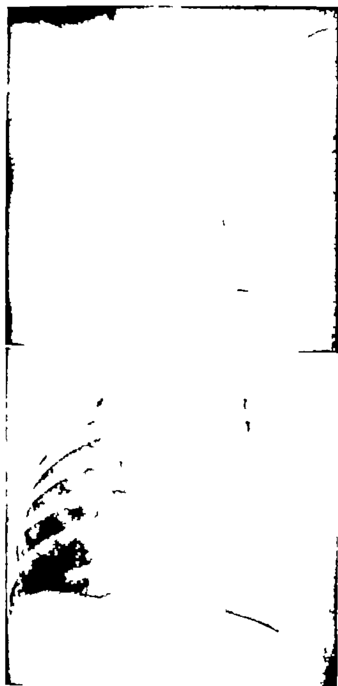
(A) Reveals an extensive paraffin pack placed in the left upper hemithorax compressing the left upper lung field. The clinical impression obtained from this patient was that the paraffin pack had become infected and it was necessary to remove it This was confirmed

(B) Line drawing of (A)

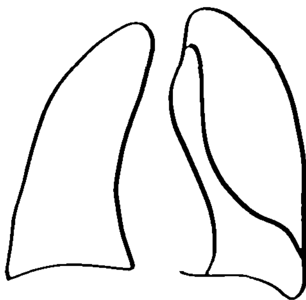
(C) Posteroanterior chest film after removal of the paraffin pack The space left filled slowly with fluid From the films it is not possible to determine that the fluid is actually extrapleural and not intrapleural. Evidence that the fluid is extrapleural but intrathoracic or lying between the parietal pleura and the chest wall is the presence of what appears to be fine rib regeneration along the pulmonary margin of this space This is only faintly visualized in our radiograph The regenerating rib occurred in this position and is in itself extrapleural, having been displaced to this position by the original pack

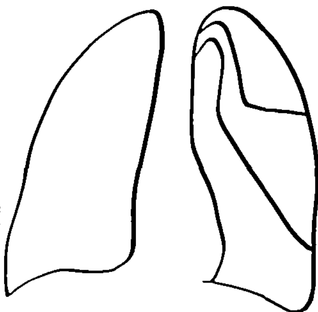
(D) Line drawing of (C)

A



B





D

C

Fig 76 *Extrapleural Intracostal Air Following Removal of Wax Prosthesis*

(A) Original chest film prior to surgical intervention. Note that an opaque prosthesis occupies the upper lateral aspect of the right hemithorax This is an extraperiosteal plombage with paraffin Likewise, the outlines of the wax pack in the subscapular space can be faintly recognized along the edge of the scapula Surgery was performed, since there was a persistent cavity underlying the wax prosthesis and it was necessary to remove the prosthesis

(B) Line drawing of (A)

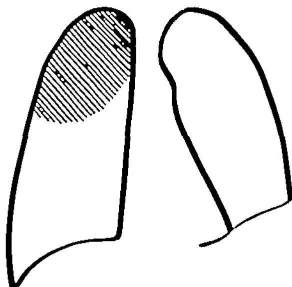
(C) Approximately ten days following right upper lobectomy and removal of the wax prosthesis An intracostal extra-periosteal air-fluid collection is noted

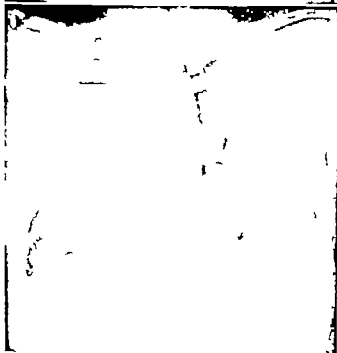
(D) Line drawing of (C)

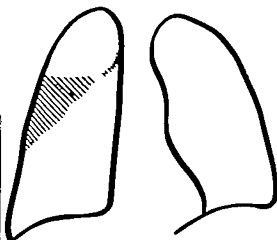
A



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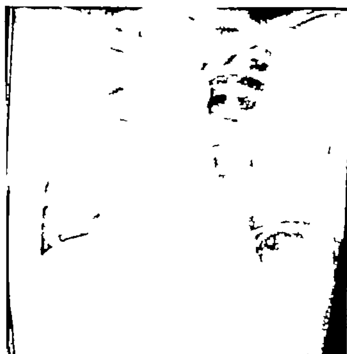
D

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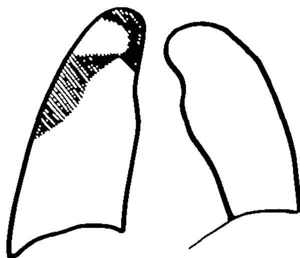
Fig 76—(*Continued*) *Extrapleural Intracostal Air Following Removal of Wax Prosthesis*

(E) Approximately one month later, showing continued resolution of air and fluid at the site of the original wax prosthesis The space is smaller and pulmonary tissue occupies a greater area than in the previous study This subscapular space may eventually become obliterated and there will be greater expansion of the remainder of the right lung

(F) Line drawing of (E)



E



F

Fig 77 *Postoperative Plate-like Atelectasis*

(A) Early postoperative film following a left upper lobectomy and resection of the superior division of the left lower lobe Crossing obliquely over the right lung field is an area which is referred to as a plate-like area of atelectasis This is a relatively frequent finding in early postoperative films in our series Postoperative sequelae on the left with pneumothorax and mediastinal exudate as well as elevated left leaf of the diaphragm are noted

(B) Line drawing of (A)

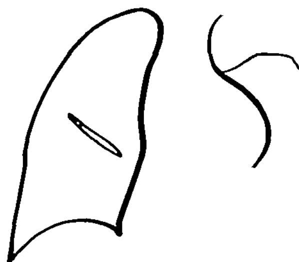
(C) Eleven days later, reveals complete clearing of the right lung and postoperative sequelae on the left The left leaf of the diaphragm remains elevated

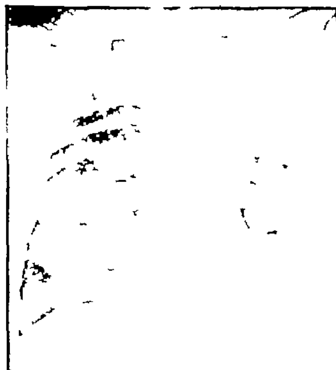
(D) Line drawing of (C)

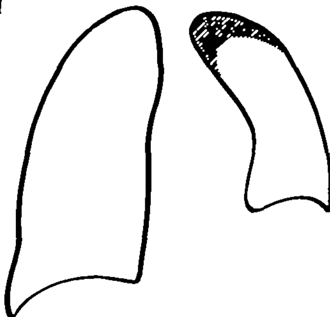
A



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D

C

Fig 78 *Small Areas of Atelectasis or Pneumonia Contralateral to the Surgical Procedure*

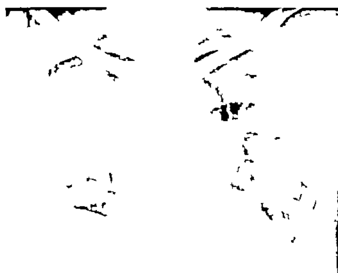
(A) Early postoperative film following right upper lobectomy twenty-four hours previously This film shows excellent re-expansion of the remaining right lung Mediastinal exudate and resection of a portion of the 5th rib is noted The left lung shows irregular areas of infiltration, the nature of which cannot be differentiated on radiographic aspects alone These areas can represent small atelectatic zones or small areas of pneumonia There was no clinical evidence for pneumonia.

(B) Line drawing of (A).

(C) Approximately seven months later, shows an excellent postoperative result with no new areas of infiltration and resolution of previously described findings. No complications are seen

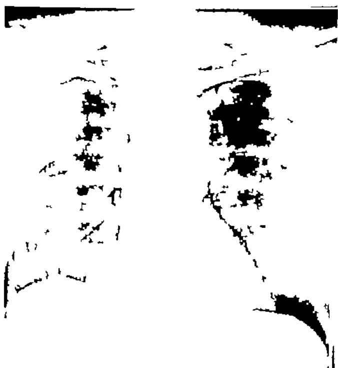
(D) Line drawing of (C)

A

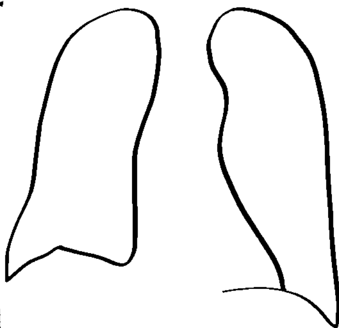


B





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D

Fig 79 *Pneumonitis, Right Base, with Subsequent Resolution*

(A) One month following right upper lobectomy and excision of small local lesions in the right middle and lower lobes, showing re-expansion of the remaining right lung to be practically complete, but there remains a small apical pneumothorax Irregular patchy areas of increased density at the right base are noted, considered to be in the nature of pneumonic consolidation There was no evidence for atelectasis The possibility of tuberculous spread cannot be eliminated on the basis of the roentgen findings alone However, subsequent observation showed the lesion to have cleared adequately, although relatively slowly.

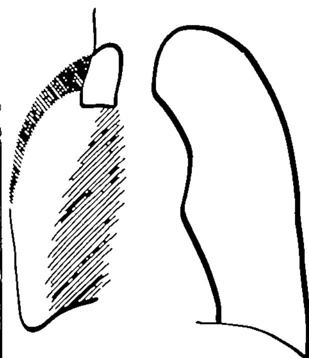
(B) Line drawing of (A)

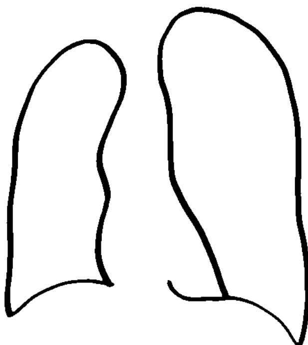
(C) Approximately two months later, reveals a good postoperative appearance with no complications There has been almost complete resolution of the previously seen infiltrates (Bronchiectasis should be considered.)

(D) Line drawing of (C)

A

B





D

C

Fig 80 *Postoperative Pneumonia Opposite Surgical Side with Subsequent Resolution*

(A) Four days following resection of the upper lobe and superior division of the left lower lobe, followed by completion of thoracoplasty. The point of interest in this study is a nonspecific area of consolidation at the right lung base. Minimal infiltration in this region had been present previous to surgery Whether this represents exacerbation of tuberculous disease or a nonspecific area of pneumonia cannot be stated on radiologic observation alone and would require further clinical evaluation

(B) Line drawing of (A)

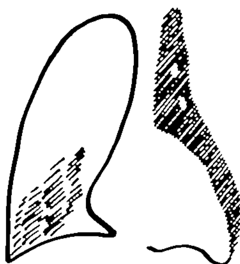
(C) More than one month later, reveals almost complete resolution of the previously described findings at the right base

(D) Line drawing of (C)

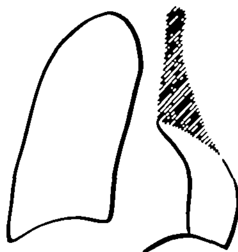
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